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ABSTRACT

This report is the culmination of a 20-month study that included 4 public hearings in cities across the United States and elicited some 10,000 pages of written comments from interested members of the public. The report examines the significance of telecommunications and evaluates how telecommunications services improve both the international competitiveness of U.S. businesses and the quality of life of U.S. citizens. It also considers the technological and marketplace trends driving telecommunications development in the United States and elsewhere, and assesses the role of regulatory and other government policies in promoting the development of a telecommunications infrastructure to support present and future national needs. Six major topics are covered: (1) the existing infrastructure and policies affecting telecommunications; (2) the importance of telecommunications to business, education, and health care, and to providing Americans with disabilities with new opportunities; (3) the continued rapid technical changes in telecommunications and the role of the government in shaping those changes; (4) a comparison of the U.S. infrastructure with the infrastructure of other countries; (5) policies that would improve efficient investment in the infrastructure by increasing competition and decreasing regulation; and (6) the means for making universal service available on an optional, low-cost basis, throughout the United States. The report contains 40 statistical tables, half of which provide information comparing the infrastructures of the United States and other countries. Appendices contain a list of the initial and reply commentators at symposium and field hearings; an alphabetical list of commentator acronyms and abbreviations; a review of a DRI/McGraw Hill study that attempts to quantify the gains in the U.S. economy's productivity that are attributable to improvements in telecommunications infrastructure; additional data requirements and recommended methodological improvements; policies of other nations on telephone company involvement in cable; and a description of the availability and affordability of telephone service in the United States. (KRN)

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The NTIA Infrastructure Report:
Telecommunications in the Age of Information

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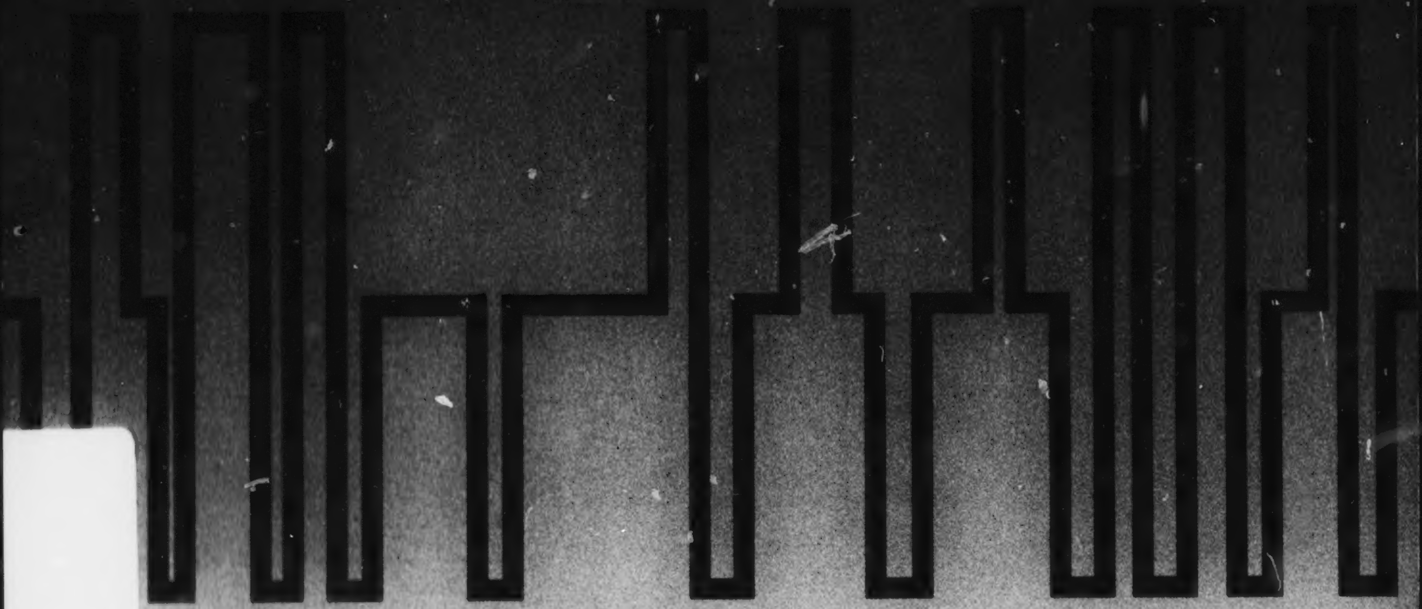

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MESSAGE FROM THE SECRETARY

This report completes a searching, comprehensive study of the current state and future development of the nation's telecommunications infrastructure. This investigation, which included field hearings and voluminous public comments, was prompted by the awareness of the many ways in which telecommunications can contribute to the well-being of the United States and its citizens. American businesses can use telecommunications to operate more efficiently, better serve their customers, and compete more effectively in the rapidly changing global economy. Advanced telecommunications can also help improve our nation's educational and health care systems, as well as the quality of life of all Americans. As importantly, telecommunications promises to give millions of disabled Americans access to economic and social opportunities than many of their fellow citizens take for granted.

The U.S. telecommunications infrastructure is, and has been for many years, the best, most efficient, and most affordable communications system in the world. However, as other nations have come to appreciate the importance of telecommunications to their economies, they have begun aggressively to deploy advanced telecommunications technologies and networks. In this environment, the United States cannot retain our preeminent position by standing still, or by continuing to adhere to outmoded notions of regulation and government micromanagement. Accordingly, this report discusses policies that can ensure that the U.S. telecommunications infrastructure will remain second to none.

This report's principal recommendation is to introduce competition into those segments of the telecommunications industry that are now insulated by statute, regulation, and judicial decree from the rigors of the marketplace. America is a nation with a deep commitment to such competition. Indeed, competition in some aspects of telecommunications, such as customer premises equipment and long distance services has achieved spectacular results in lower prices, increased diversity and technological innovation. It is time to introduce competition into other telecommunications markets, as well. Where full competition is not feasible, we recommend regulatory approaches that replicate, to the extent possible, the incentives for efficient behavior provided by competitive markets.

Finally, an essential element of an advanced, state-of-the-art telecommunications infrastructure is widespread, affordable access to that infrastructure. As the report demonstrates, such access will afford all Americans an equal opportunity to share in the almost boundless economic and social potential of telecommunications.

Robert A. Mosbacher
Secretary of Commerce

NTIA Special Publication 91-26

THE NTIA INFRASTRUCTURE REPORT

Telecommunications in the Age of Information

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Executive Summary

An advanced telecommunications infrastructure can help the United States meet important economic and social challenges into the next century. In this report, NTIA examines the significance of telecommunications and evaluates how telecommunications services improve both the international competitiveness of U.S. businesses and the quality of life of U.S. citizens. This report considers the technological and marketplace trends driving telecommunications development in this country and elsewhere, and assesses the role of regulatory and other government policies in promoting the development of a telecommunications infrastructure to support present and future national needs.

The Infrastructure

- The U.S. communications infrastructure includes all facilities used for the movement of information, including those used for mass media and telecommunications, print and film communications.
- This report focuses on policies affecting telecommunications, in order to conduct a comprehensive review of the complex regulatory and policy issues associated with this heavily regulated market segment.

The Importance of Telecommunications

- U.S. businesses can harness telecommunications to operate more efficiently, better serve their customers, and compete more effectively in a global economy.
- Telecommunications can help deliver critical services such as education and health care more cheaply, more extensively, and more equitably.
- Millions of Americans with disabilites can use telecommunications to gain access to economic and social opportunities that many of their fellow citizens take for granted.

Networks in Transition

- The rapid technical changes in telecommunications will continue, with trends towards increased digitization, separate signalling systems, and increased customer control of facilities.
- Because industry participants continually harness technical advances in shaping services to meet market demand, the mix of equipment currently employed in domestic networks reflects diverse and evolving technologies.
- The report recommends continued reliance on the private sector for standards development, recognizing that there are rare cases where government intervention is justified. In addition, it recommends that the FCC and NTIA make a priority of monitoring the progress of standards developments.

International Comparisons - International comparisons of infrastructure development can provide useful insights.

- The report's comparative analysis of several investment and technological measurements for the seven largest countries, based on national income, confirms the notion, widely expressed in the comments, that the United States is a nation with an advanced telecommunications infrastructure, a very high access-line density, a robust level of telephone usage, and a heavy emphasis on modernization.

- Although only limited projections are available, other countries may be planning to deploy several new technologies, such as digital switching and Signalling System 7, more rapidly than companies in the United States.

Infrastructure Policies - Efficient investment in the infrastructure can be improved through increased competition and decreased regulation in telecommunications markets.

- The report recommends ways to eliminate the distortions that government can impose on investment decisions in the markets for customer premises equipment, interexchange service, and local exchange service.

- The report strongly advocates increased competition in local exchange markets, and describes interconnection policies designed to promote such competition.

- The report advocates the elimination of government-imposed barriers to competition, such as the manufacturing restriction in the AT&T Consent Decree and the cable/ telephone company crossownership prohibition.

- The report discusses the importance, when full competition is not feasible, of regulatory approaches that replicate, to the extent possible, the incentives for efficient operation and investment that characterize competitive markets.

Universal Service

- The report outlines a new vision for universal service, Advanced Universal Service Access—Advanced USA—that has as a goal, the availability of advanced features, on an optional, low-cost basis, throughout the United States, as justified by demand for them.

- This proposal relies on the widespread introduction of local exchange competition to lower the costs and increase the availability of telephone service, including advanced services.

- The report concludes that the present system of pricing for local telephone service still contains extensive and hidden cross-subsidies that promote neither efficiency nor universal service.

- The report proposes that to the extent subsidies are found to be desirable for universal service purposes, they be made explicit and carefully targeted to those who are in most need of assistance in obtaining telephone service.

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Summary of Findings and Recommendations

Chapter 2—The Infrastructure

Findings

- The U.S. communications infrastructure includes the facilities used for mass media services, such as broadcasting and cable television service, and telecommunications, such as telephony. It also includes other facilities used for delivery and dissemination of information throughout the nation, including those of the Postal Service, Western Union, and the express firms that deliver letters, telegrams, and packages, as well as the facilities that support the print media and the motion picture industry.
- The telecommunications portion of this infrastructure encompasses the many facilities offered by the traditional common carriers—local exchange carriers (LECs) and interexchange carriers (IXCs), as well as metropolitan area networks (MANs), local area networks (LANs), value-added networks (VANs), teleports, cellular radio systems, shared tenant services (STS), satellite carriers and private networks. The term would also include new transmission systems that are not yet fully developed, such as radio-based personal communications services (PCS), once they have been deployed.
- The telecommunications infrastructure also encompasses the various types of terminal equipment, or customer premises equipment (CPE), that enable users to originate and terminate communications.
- Monopoly and government regulation are still quite extensive with respect to local telecommunications facilities and services. Much of the public policy debate in telecommunications in this country concerns "local" issues—*e.g.*, the respective roles of competition and regulation in local exchange markets, and the rate of deployment of advanced technologies in local networks. Accordingly, we address this part of the domestic telecommunications system in some depth.
- A fundamental objective of this study is to identify policies that will give users access to telecommunications capabilities

that efficiently and equitably meet their communications needs. Competition can help meet these goals by promoting efficient deployment of advanced public switched networks—the telecommunications facilities on which most users, and especially residential users, rely—as well as other portions of the telecommunications infrastructure.

Recommendation

- Policies to promote efficient infrastructure development should neither artificially favor nor disfavor particular types of technologies, services, or networks. Such policies will permit entrepreneurs and users best to evolve the U.S. telecommunications system to meet consumer needs.

Chapter 3—The Importance of Infrastructure

1. Telecommunications as a Factor of Production

Findings

- The record in this proceeding clearly demonstrates that American businesses of all sizes and types are now using telecommunications extensively to reduce costs, increase productivity, and improve service to their customers. But many of the most sophisticated applications involve private networks used for internal communications by large companies and other big users. The public switched network currently provides fewer alternatives for smaller businesses.
- The benefits of telecommunications to U.S. businesses and to the American economy are clear and pervasive; indeed, greater use of telecommunications could transform the distribution sector of the economy and make a substantial contribution to the efficiency of manufacturing.

Recommendation

- Government should ensure that a competitive environment exists in which U.S. firms can continue to develop the kinds of services and capabilities that U.S. firms and consumers need.

2. Telecommunications and Economic Development

Findings

- The availability of adequate, reliable telecommunications facilities can facilitate economic development. This linkage is particularly evident in rural areas where, like railroads and highways, telecommunications facilities can reduce the geographic isolation of rural communities and make those communities attractive to business. But the availability of advanced telecommunications can play an important role in urban economic development as well.

- Even the most advanced telecommunications infrastructure cannot alone guarantee the economic health and prosperity of the United States. Telecommunications does not obviate the importance of a well-educated, hard-working labor force, reasonable tax rates, affordable real estate, and other factors. What telecommunications can do is help reduce geographic barriers to competition.

3. Telecommunications and Delivery of Critical Services

Findings

- *Education*: Telecommunications can be a powerful tool for delivering educational services to students of all ages. Such applications can include the supercomputer networks proposed for research purposes, or can help students in small or poor school districts (rural and urban alike) to share in increased educational opportunities.
- Distance learning can enable teachers in the most isolated areas to acquire and hone skills that will enhance the educational experience for their students. It can allow colleges and universities to reach out to non-traditional student populations, and permit more citizens to experience the rewards of lifetime learning.
- Although distance learning will require educators to wrestle with contentious institutional issues, it can help create greater choice in education by enabling students to receive educational services from sources that they and their parents choose without regard to geographic proximity.
- *Health Care*: Telecommunications can improve delivery of health care information to both practitioners and consumers and have a substantial beneficial effect on the quality of health care. Some health care providers are using telecommunications to improve the provision of services in underserved areas.
- Given the relatively undeveloped state of telemedicine, more study is needed to determine which applications and serving arrangements are most cost effective in meeting the needs of health care professionals and their patients.

4. Quality of Life

Findings

- Greater use of telecommuting can generate economic and social benefits for U.S. businesses and citizens. For workers, telecommuting can significantly reduce stress and increase job satisfaction. Telecommuting can help employers reduce operating costs and better attract and retain skilled workers. The available evidence suggests that telecommuting employees are as productive and in many cases, more productive than their office-bound colleagues.
- While the current capabilities of the domestic telecommunications infrastructure are sufficient to support substantial telecommuting activities, further development could permit even more extensive work-at-home programs. Many existing telecommuting programs involve data entry and computer processing applications with relatively simple telecommunications requirements. Performance of other tasks at home, including work that involves extensive interaction with people, or knowledge-intensive tasks such as interactive computer-aided design or remote software testing, may require far more advanced telecommunications capabilities, such as simultaneous voice and data transmission, high capacity data transmission, or two-way transmission of high resolution images.

Recommendation

- Telecommunications providers should consider in their planning and design processes the needs of disabled persons, and the ease of operation of these offerings by such persons. The needs of disabled Americans should be well-integrated into telecommunications system planning to avoid expensive and disruptive retrofitting in response to regulatory or statutory requirements. NTIA will coordinate with the FCC and the Department of Health and Human Services to explore ways of seeking such industry action.

Chapter 4—Networks in Transition

1. Network Services, Features, and Their Development

Findings

- Today's public and private networks incorporate a wide variety of older technologies and newer, highly advanced technical alternatives. For example, by 1994, over 99 percent of BOC access lines are projected to be connected to computer-controlled switches; over half of those access lines will be served by digital switches. GTE plans to serve 87 percent of its access lines by digital switches by 1994. Further, by 1994, the BOCs and GTE will double the amount of fiber optic cable that they had deployed in 1989 (measured in percentage terms).

- As new technologies and media become cost-competitive compared to existing plant, they become preferred alternatives to the degree they increase the ease of accommodating new growth or adding service features. Thus, telecommunications services and features are built on and depend on a blend of new and old technologies, in a mix capable of delivering the desired performance at a particular cost.

Recommendation

- With the rapid pace of technical progress, investment decisions regarding telecommunications facilities must accommodate the changing nature of demand, which includes traditional voice traffic and, increasingly, data and video. Investment decisions must consider how adaptable networks will be in meeting changing demand, and judge when plant replacement (as opposed to plant modification) is appropriate.

2. Network Evolution: Issues

Recommendation

- Investment decisions often require network operators to balance their commitments to current technology with the anticipated development of better technologies in the future. This choice is difficult. Large-scale technology deployment decisions should not be so inflexible as to foreclose future investment decisions that may depend on technology still under development. Today's technology implementation schemes must anticipate and provide, not foreclose, opportunities to develop tomorrow's services built on future technology.

3. Network Evolution: Implementation

Recommendation

- Government should not impede regulated telecommunications providers from investing at a rate that is responsive to both market demand and technical opportunities. This "efficient" investment would not allow obsolete technology to be employed beyond its economic life. Nor would it result in an over-investment in, and over-commitment to, current "mature" technologies, delaying the opportunity to introduce future technologies as they develop. The goal should be to encourage a healthy mix of network technologies that can provide services that respond to customer needs.

Findings

- The use of new technologies can increase options and opportunities for users, raising issues of network control. The possibilities for flexible distribution of control and "intelligence" among CPE and public and private networks are a source of some tension among network operators, users and equipment manufacturers. However, they also present opportunities for flexible service offerings if all interconnected equipment can work together. The rapid growth of advanced signalling systems, expected to serve about 73 percent of BOC access lines by 1994, can provide an efficient communications pathway for network control and new service facilities.
- An important challenge for the industry is to evolve "number planning" activities to accommodate the proliferation of service providers in a manner that promotes competitive market developments, and gives customers access to a variety of options, while preserving dialing convenience.
- Experience has shown that because increasingly large volumes of traffic, approaching the gigabit range, are moving through broadband transmission and switching facilities, a failure in a system component could potentially result in a large service outage. Further deployment of broadband facilities will augment the scope of contingency planning efforts. Increasing network complexity will demand more advanced operational, diagnostic, and control equipment.
- Because of the growing importance of telecommunications to the U.S. economy, and to public health and safety, service outages have increasingly severe consequences. Accordingly, steps should be taken both to reduce the chances of such outages occurring and to lessen the customer dislocations if disruptions do occur.
- Competition in telecommunications services markets will give firms strong incentives to provide high quality, reliable service, or risk losing customers to rival companies. Thus, firms subject to competition can be expected to make investments and establish procedures that will minimize potential service outages.
- Nevertheless, competition will likely cause an expansion in the number and types of networks and providers, thus potentially

increasing the complexity of ensuring certain aspects of overall service reliability. This complexity can be addressed by increasing the flow of information about network problems between government and private firms, as well as among the firms themselves. Through this process, regulators can gather vital information about when service disruptions occur, how they happen, and how they affect users.

4. Standards and Technology Trends

Findings

- Current domestic and international standards activities appear to reflect increased future reliance on the following capabilities:
    - Digitization of networks and higher capacity of signalling, switching, transmission, and terminal components, with the design goal of meeting user needs by providing greater flexibility, accuracy, and efficiency.
    - Separate, out-of-band signalling networks, such as Signalling System 7 (SS7), to speed call processing by several orders of magnitude and increase the efficient use of network resources.
    - Greater user control of network facilities and a variety of integrated voice, video, and data services, perhaps including services that can be customized for each call.

  The substantial standards-setting and technical activity in these areas suggests that the greatest question concerning such developments is when the nation will have them.

5. The Standards Process

Finding

- The role of government in the standards setting process in the United States is appropriately a limited one. The specification of particular telecommunications standards or technologies is a task performed better by the private sector, with input from a broad range of interests, including manufacturers, service providers, and users.

Recommendations

- Telecommunications standards play an important role in U.S. infrastructure development. NTIA will continue to work for standards development processes that are efficient, fair, and open to all. Standards organization practices should permit full consideration of issues as a means to develop consensus among participants.

- The task of standards-setting is best left to the private sector, without governmental interference. We recognize that there may be rare cases where FCC or NTIA action to expedite the standards process could be justified. This could be necessary in areas, such as the development of interconnection standards, that would require competitors to agree on matters that could directly affect their relationships. Government intervention could include mediation among conflicting interests or a mandate to industry to develop standards by a time certain, leaving the actual development of standards to the private sector.

- Any intervention, however, should be limited to cases where there is a specific and clearly identified market failure, and where the consequences of that failure outweigh the risk of a regulatory failure (i.e., forcing the resolution of a standard too early in the development of a technology.)

- NTIA and the FCC should recognize and be alert to the consequences of standards development for the infrastructure. Both agencies should therefore make a priority of monitoring the progress of standards development.

- Telecommunications networks should be able to interconnect and interoperate smoothly. This is particularly important for public networks as competition grows in the provision of telecommunications services, and competing networks develop in response to user needs. Standards organizations should, through their own initiative, identify systematically and resolve expeditiously issues that affect such interconnection and interoperability, ultimately developing new standards when necessary.

Finding

- Implementation agreements and conformance tests of complex standards can clarify existing ambiguities, demonstrate the workability of various options, and ensure that products from different vendors can work together. Users can benefit substantially from industry efforts to further refine standards after their initial development. The importance of such efforts has continued to increase with the proliferation of service and equipment vendors.

6. Developing Network Technologies: Government's Role

Recommendation

- Government policies should not attempt to direct the selection of particular technologies or the pace of infrastructure investment by or for private-sector firms. Such government-controlled infrastructure development would likely be misdirected from the start and would not be flexible enough to respond efficiently to the demands of rapidly evolving telecommunications technologies and markets. Rather than mandating investment levels and technology choices, the FCC and the states should encourage further infrastructure development by removing the government-imposed barriers to competition and efficient investment in telecommunications facilities and services that characterize many telecommunications markets.

Chapter 5—International Comparisons

Findings

- NTIA's comparative analysis of telecommunications investment, quality, usage, and technological deployment focuses on the seven largest countries in the world, based on national income. It shows no consistent leader across the various types of comparisons.
- Our comparisons show that U.S. telecommunications firms:
    - feature one of the most developed public telecommunications systems with respect to per-capita telephone penetration and network usage;
    - spend the highest percentage of their average annual investment on network modernization;
    - currently lead in the conversion to electronic switch technology;
    - rank in the middle ranges in such areas as average investment per line, deployment of such technologies as digital switches and SS7, and service quality; and
    - trail, and according to some estimates, are projected to trail other large countries in the implementation of ISDN, digital switching, and SS7.
- The significance of these findings is not clear-cut. With such technologies as digital switching, fiber optic transmission, and

at an efficient rate in the United States, not whether this country is "keeping up"with our trading partners. The continued prevalence of monopoly control and centralized government planning for telecommunications in many of these countries creates the real possibility that inefficient levels of investment (whether over- or under-investment) may be taking place. Nevertheless, the ambitious deployment schedules of other countries should cause U.S. firms to evaluate their own plans, and U.S. policy-makers and regulators to reexamine policies that may be hindering the achievement of efficient levels of investment in infrastructure development in this country.

- In terms of service quality, the one common indicator shows that each of the seven countries possesses a call completion success rate of 97.5 percent or better. In the United States, despite sporadic events brought about by natural disasters (*e.g.*, the Hinsdale, Illinois, central office fire) or aberrational technical problems (such as the software-induced service disruptions to the AT&T network that occurred in January 1990 and the networks of Bell Atlantic and Pacific Telesis in late June and early July 1991), the service quality performance of common carriers has been good and generally getting better since the AT&T divestiture.

Recommendation

- NTIA recommends that a more coordinated and comprehensive approach be adopted to generate on a regular basis useful data for international comparisons. The ITU and OECD should establish a center to develop data requirements and common measures that would permit meaningful comparisons of infrastructure on an intercountry basis.

Chapter 6—Government Policy and Infrastructure Development

Recommendations

- The soundest way for government to encourage efficient infrastructure development is through removal of unnecessary regulation and promotion of a competitive telecommunications marketplace. This approach will provide a decentralized, independent, and market-driven set of incentives and checks on any telecommunications provider's investment decisions.
- When workable competition cannot occur, regulators should adopt approaches that replicate, to the extent possible, the incentives for efficient operation and investment that characterize competitive markets.

incentives for efficient operation and investment that characterize competitive markets.

1. Customer Premises Equipment

Finding

- The CPE marketplace confirms the potential benefits of competition.

Recommendation

- Given the robustly competitive state of the CPE marketplace, the principal focus for policymakers should be to preserve the gains that have been made to date.

2. Interexchange Infrastructure

Findings

- Interexchange competition is driving useful investment in advanced technologies.
- The FCC's implementation of price cap regulation for AT&T is an important step in improving the functioning of this market.

Recommendation

- NTIA supports the FCC's recent action to lessen regulation of AT&T's large business services, and will continue to monitor the development of competition in this area.

3. Local Exchange Infrastructure

Findings

- *AT&T Consent Decree*: The manufacturing restriction of the AT&T Consent Decree hampers development of the U.S. telecommunications infrastructure. The evidence suggests that the manufacturing restriction slows research and development, particularly for new telecommunications products. To the extent that government regulation impedes development of those products, it hinders deployment of the networks and services built upon them.
- Removing the manufacturing restriction, when coupled with regulatory safeguards to prevent anticompetitive behavior by the BOCs, will have salutary effects on infrastructure development.
- The Decree court's recent decision to lift the information services restriction will enhance the growth potential of new and innovative information services by increasing the BOCs'

incentives to invest in the infrastructure needed to make such services available.

- The inclusion of the BOCs, with their access to many of the nation's telecommunications users, in the information services market will permit U.S. telecommunications facilities to develop to the extent that best serves the American public. Regulatory safeguards, largely already adopted by the FCC, can effectively address concerns about potential anti-competitive conduct.

Recommendations

- Cable/*Telephone Company Infrastructure Development*:[†] NTIA recommends the removal of the current telco/cable cross-ownership restrictions in the Cable Communications Policy Act of 1984 and FCC rules. LECs should be able to provide or package video programming themselves over their own facilities, so long as they also:
  - offer video transmission capacity on a common carrier basis to unaffiliated program providers, and
  - are subject to FCC safeguards designed to prevent discrimination against competitors and improper cross-subsidization.
- NTIA continues to endorse the "common carriage" requirement of its original "video dial tone" proposal. For regulatory purposes, video services can generally be treated as another type of "enhanced service" for which the FCC's Open Network Architecture (ONA) regime should be generally applicable. The FCC should examine in a rulemaking proceeding whether video services require any modifications or additions to the ONA rules in order to protect against discrimination or promote efficiency in this particular marketplace.
- The FCC's accounting and cost allocation rules can adequately control the danger of cross-subsidization of a LEC's programming activities by its regulated operations.
- LEC entry into the video programming business would be one important way to expand competition in the provision of video programming to the home, offering direct competition to incumbent cable systems. In addition, requiring LEC channel capacity to be made available on a common carrier basis

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[†] This section and other parts of this report addressing telephone company entry into cable television are being issued under the supervision of Thomas J. Sugrue, Deputy Assistant Secretary and Deputy Administrator of NTIA. Assistant Secretary Janice Obuchowski currently is recused from participating in the discussion of this particular issue.

would multiply opportunities for entry by independent program providers.

- Electronic mass media markets are characterized by a wide variety of vertical arrangements and cross-investments among producers, packagers, and distributors. In particular, the cable television industry has made extensive investments, in return for ownership interests, in much of the currently available cable network programming. In light of these marketplace realities, potential competitors, including LECs, should also have the opportunity to invest in the development of their own programming to compete against incumbent cable systems.

Findings

- LEC common carriage of unaffiliated programming, combined with LEC ability to provide programming, will promote, not hinder, diversity. A prohibition on LEC participation in programming over its own facilities would limit a voice—that of the owner of those facilities—from being heard.
- Allowing LECs to own, control, and provide video programming over their own facilities, subject to effective safeguards, could promote infrastructure development by increasing their incentives to deploy integrated broadband systems and other advanced network capabilities.
- Government regulations that have the effect of limiting the types of services for which a new technology can be used are generally inefficient and anticompetitive, and thus tend to retard investment in that new technology. The current telco/cable crossownership rules are having such an effect with respect to investment in broadband public network technology.

4. Forms of Regulation

Finding

- *Improving "traditional" Regulation*: Recognizing that it will be some time before local exchange markets are workably competitive, and that LECs will remain subject to federal and state regulation in the interim, we recommend reforms to current regulatory practices.

Recommendation

- NTIA supports the continued replacement by the states of rate of return regulation with some form of incentive regulation. Because incentive regulation generally induces regulated firms to operate more efficiently, it can result in regulated services being provided at lower prices and at lower cost than would be the case under rate of return regulation. At the same time, it can provide incentives for efficient levels of investment in infrastructure development.

- Many forms of incentive regulation require a regulated firm to share a certain portion of profits earned in excess of an authorized rate of return with ratepayers or for some other purpose. Such sharing mechanisms could be employed to further infrastructure development goals, particularly the universal service components of those goals.

Finding

- Although depreciation reform will increase the incentives for efficient telecommunications investment, we caution that accelerated depreciation, by itself, does not guarantee either that investments will be made or that the investments made will be optimal or socially desirable.

Recommendation

- *Regulatory Depreciation Practices*: Although there has been significant progress made in accelerating regulatory depreciation rates in recent years, the FCC and the states should continue to pursue regulatory depreciation reforms aggressively. Adherence to historical depreciation practice in the face of rapid technological change has meant that the investment assets on regulated firms' books of account are consistently and, in many cases, substantially overvalued.

5. Local Exchange Competition[‡]

Findings

- Technological and marketplace changes are steadily increasing the potential for competitive entry in major parts of the local exchange service market. Deployment of digital technology promises to alleviate the capacity constraints that have limited cellular radio's ability to compete with local exchange telephone service. Installation of fiber optic transmission facilities by cable television systems will substantially improve their ability to compete with LECs. Future development of PCS will further enhance the prospects of local exchange competition from radio-based services.

- Although it is now only beginning, various forms of local exchange competition have been endorsed, and are being implemented, in several states. Some 34 different firms are now offering or planning to provide alternative local telecommunications services in more than 38 cities in 26 states.

[‡] This section and other parts of this report addressing local exchange competition are being issued under the supervision of Thomas J. Sugrue, Deputy Assistant Secretary and Deputy Administrator of NTIA. Assistant Secretary Janice Obuchowski currently is recused from participating in the discussion of this particular issue.

- Even the limited competition that has occurred to date has caused incumbent LECs to reduce their rates, improve service quality, expand their service offerings, and upgrade their networks with advanced technologies like fiber optic cable. The clear benefits that have stemmed from the introduction of competition into the interexchange service and CPE markets provide promise that similar benefits will follow from local exchange competition.
- There is no compelling reason to believe that local exchange competition is not feasible. The "natural monopoly" model for local exchange service does not provide a convincing rationale for barring competitive entry into this market. On the other hand, there is evidence to suggest that a major barrier to increased competition in much of this marketplace is government regulation, including direct prohibitions on entry.

Recommendations

- The FCC and the states should remove existing legal barriers to entry into the local exchange services market. While an open entry policy is not without risks, the likely benefits of competitive entry outweigh the potential costs.
- Regulators should ensure that sufficient radio spectrum is available to permit efficient growth of radio-based telecommunications services, such as cellular radio and PCS. One way to accomplish this would be to create economic and regulatory incentives to encourage radio-based users to switch to wire media in congested areas, when consistent with other public policies.
- Government regulators should facilitate competitive entry by mandating that LECs provide efficient interconnection opportunities to other firms that provide local exchange services to the public. We support the FCC's rulemaking on local access interconnection with respect to special access services subject to federal jurisdiction. We also recommend that state commissions continue their innovative proceedings to introduce mandatory local exchange interconnection.
- While regulators should require interconnection in appropriate circumstances, they should not attempt initially to develop a standard interconnection agreement. There is likely to be

considerable variation from state to state, community to community, and, perhaps, provider to provider with regard to network design, space availability, and technical requirements.

- However, after a reasonable period of initial experimentation with privately negotiated agreements, regulators should require the tariffing of interconnection agreements in order to facilitate regulatory review and, thus, ease the regulators' task of detecting and remedying unreasonable or discriminatory rates, terms, or conditions. As importantly, tariffing could also be a valuable tool for promoting technical standardization, if that is deemed necessary.
- To permit incumbent LECs to respond to the new entrants, and to ensure that entry is economically efficient, existing pricing policies must be substantially reformed. LECs should be afforded significant pricing flexibility when they face competition. Competitive policies will also require a transition to cost-based pricing.

Chapter 7—Universal Service

Recommendations

- The "universal service" concept, which has been a cornerstone of national telecommunications policy at least since enactment of the Communications Act of 1934, should be updated to address Americans' future telecommunications needs.
- The current "basic service package" for universal service purposes should be defined to include certain "advanced" features, such as touchtone dialing, access to emergency services (such as 911), access to 800 and 900 services, equal access to IXCs, and access for the hearing impaired (such as TDD).
- It is in the national interest that all U.S. citizens have the opportunity to benefit from an advanced telecommunications infrastructure. To further this national interest, the FCC and the states should ensure that, as our telecommunications networks evolve, all residential users have the opportunity to obtain capabilities generally offered by telecommunications service providers to residential users in the United States—Advanced Universal Service Access (Advanced USA). Thus, instead of seeking only to provide a specified package of

services, the FCC, the states, and the telecommunications industry should seek to make advanced network capabilities and access to non-network based services available to all users on an optional, low-cost basis. Policymakers should generally define, in a technologically-neutral way, the features or functionalities that are elements of Advanced USA.

- States should change their pricing policies so that if a new service or feature incurs no identifiable separate costs, its price should be set at zero and included as part of that basic service package made available to subscribers. With other new services or features, we recommend as a general matter that they be offered on an optional basis and priced to the degree possible at or near "cost." Either competition or a well-crafted incentive regulation scheme will accomplish this objective. Strict adherence to a marginal cost pricing basis is not essential since, in practice, marginal costs may be difficult to determine and some reasonable level of contribution to common costs is acceptable. What should be avoided is requiring telephone companies to price new services or features substantially above cost, which can seriously diminish their utility to middle and low-income consumers.
- The complex, unfocused, and inefficient subsidy system that pervades regulatory pricing policies for many telecommunications services must be reformed. Much of this system can be eliminated without a sacrifice in equity and with substantial benefits in economic efficiency. To the extent it is determined that some continuing subsidies are needed to fulfill universal service goals, the FCC and the states should carefully narrow and target subsidies to high cost areas and needy users to keep their rates affordable. These narrowed subsidies should be funded by explicit revenue-raising mechanisms, such as a "universal access" surcharge, that minimize efficiency losses and distortions to the competitive process. Increased reliance on competition should prove substantially superior on *both* efficiency and equity grounds to the present system of monopoly and broad, unfocused cross-subsidies.

Chapter 1 Telecommunications in the Age of Information

I. INTRODUCTION

This report is the culmination of a 20-month study that included four public hearings in cities across the United States and elicited some ten thousand pages of written comments from interested members of the public.[1] The purpose of this report is to determine what government can do to foster competitive markets to ensure that the American people will have the best possible, affordable telecommunications infrastructure. This study does not describe some ideal network design that would be suitable at all times and in all places. What it does do is describe a process that can help produce the best infrastructure for the citizens of this country.

Such recommendations must be grounded solidly on facts about the existing state of the telecommunications infrastructure and the effects that government intervention has had upon it. In the last analysis, however, the telecommunications network we deploy should reflect the wants and needs of our people. It should be an expression of the American national spirit.

The dominant theme of this nation's history has been the quest for freedom. That has always implied resistance to unnecessary government interference but, to an increasing extent in recent years, it has also expressed itself as a desire for greater control over the personal circumstances of life. For most Americans, that includes control over one's economic fate—not necessarily for wealth, but for a sense of mastery over one's affairs.

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[1] NTIA began this comprehensive study of the domestic telecommunications infrastructure by publishing a Notice of Inquiry in the Federal Register on January 9, 1990. *See Comprehensive Study of the Domestic Telecommunications Infrastructure*, 55 Fed. Reg. 800 (1990) (Notice). Recognizing the potential risks to users and to the economy if the wrong choices are made, we wanted to develop an extensive and complete record before making any judgments on the appropriate policies with regard to the U.S. telecommunications system.

More than 130 parties submitted comments in response to the Notice; more than 40 filed reply comments. *See* Appendix A. Pleadings were submitted by a wide range of interest groups, including telecommunications service providers of all stripes, state regulators, state and regional development organizations, large telecommunications users, consumer groups, and academics. For simplicity, unless otherwise noted, all citations to "Comments" and "Reply Comments" shall refer to pleadings filed in response to the Notice.

In addition, NTIA conducted four field hearings and a symposium on infrastructure and rural development. *See* Appendix A. The comments and hearings have been extremely helpful to our study.

- For working Americans, the vast majority of new jobs are being generated by small businesses. Thus, for this country, it is especially important to ensure that advanced telecommunications will be accessible to small employers and sole proprietorships, not just big corporations, big institutions, and big government.

- For the 43 million disabled Americans, the telecommunications network must provide access to employment and essential services.

- For older Americans, the infrastructure should include capabilities that will prolong the years when they can continue to be masters of their own households, with remote access to medical care and other necessities.

- For students of all ages, distance learning via telecommunications can accelerate progress toward a new kind of freedom that is being advocated as a pathway to quality learning: the freedom to attend the educational institution of one's choice.

- For Americans with strong personal ties to their communities, affordable long distance communications with advanced business capabilities will empower people to find employment where they are, or where they choose to be, without sacrificing important interpersonal relationships.

- For parents with young children, such empowerment should imply an ability to pursue meaningful careers without sacrificing the full richness of family life. Today, millions of Americans telecommute to clerical jobs by transmitting data at low speeds over the existing copper network. In the future, professionals and others will engage in face-to-face negotiations from their homes with videoconferencing and high-speed facsimile services.

While telecommunications can serve as a substitute for travel, the future is unlikely to find the citizens of this country at rest for long. Of all our treasured liberties, few are more American than the importance we attach to freedom of geographic mobility. Communications technologies have evolved to serve mobile Americans. Most Americans in cars enjoy the use of broadcast radio, and the use of cellular telephones is growing explosively. In the future, telephone numbers will follow people wherever they choose to go, close at home or far away, in motion or at rest, through advanced new forms of radio communication and through the "virtual" forms of travel that fiber optics and other broadband technologies can support.

These prospects are emerging against a changing background of social and economic realities in our society at large. The Information Age is upon us, but we have seen only a glimpse of its ultimate outlines. Developments in the information processing industry, such as the steady acceleration of computing speed and power, and the rapid diffusion of computers among businesses and households, have opened economic and social vistas unimagined even twenty years ago. With the cost of information processing power dropping by some 50 percent every year, it seems likely that the impressive accomplishments of the past ten years merely foreshadow more spectacular achievements in the future.

However, the full potential of the Information Age cannot be realized simply by continued increases in society's ability to manipulate, process, and create information. The power to manipulate information in fractions of seconds is useful only to the extent that it provides ready access to information in a usable, understandable form. Businesses can take advantage of their enhanced capacity for processing information only if that information can be distributed quickly and economically among their many plants and offices. Society can benefit from the creation of ideas only if they can be disseminated throughout the population, thus providing the spark for further creativity.

In short, although the power to create and manipulate information is critical to capturing the promise of the Information Age, so also is the ability to move that information from point to point. This latter capability is, of course, provided by telecommunications, and it is why the U.S. telecommunications infrastructure is commonly referred to as the "highway" of the Information Age. It is also why the current and future state of that infrastructure is of increasing concern to policymakers at all levels of government.

The U.S. telecommunications system has historically been the best in the world, and the record compiled in this proceeding supports the conclusion that, on an overall basis, this is still the case. However, other countries are moving rapidly to deploy the most modern technologies in their national networks. Although only limited projections are available, the U.S. may lose its preeminence by the middle of this decade. U.S. firms need to keep pace with advances in the speed, power, and flexibility of modern telecommunications and computer equipment in order to meet the information needs of American business and residential users alike.

We can best achieve that objective, not by mimicking the deployment plans and organizational styles of other nations, but by doing better what we do best. A free, open, and competitive marketplace is the preferred course for U.S. telecommunications development, not only because it is better in an absolute sense than top-down, government-directed planning, but also because it best suits the American national character. Marketplace competition, economic freedom, and entrepreneurship have been the key organizing principles of our economic activity, and a source of U.S. strength in international commerce. To the extent that this country has pursued competition and freedom of choice for telecommunications users, the results have been uniformly beneficial, and in some cases, spectacular. The many benefits that competition has produced in the provision of customer premises equipment (CPE) and long distance telephone service overwhelmingly confirm that these choices have been wise. To the extent that our system has fallen short, or is in danger of doing so in the years ahead, the failure has not occurred because our policymakers have relied too much on the American way, but because they have relied on it too little.

Large segments of the telecommunications industry have been relatively immune to government's pro-competitive initiatives. Thus, local exchange telephone services in most communities are still being provided either on a monopoly basis or by a single dominant firm. The time has come for government to open the local exchange services market to competitive entry.

But failures of omission have not been government's only shortcoming. A striking feature of the U.S. telecommunications industry is the extent to which government itself has established restrictions, or outright prohibitions, on the development of competition among firms operating in different parts of the industry. In an area as dynamic as telecommunications, government policies ideally should promote competition by facilitating the free flow of resources—capital, technology, expertise—across industry sectors so that firms can adjust their operations to take advantage of rapidly changing marketplace and technological conditions and, ultimately, better serve their customers. Instead, we have often done just the opposite by creating regulatory barriers between industries that might otherwise compete with each other.

This is not to say that removing barriers to competition will immediately produce full and active competition in all telecommunications markets. Even in an ideal political and regulatory environment, some segments of the telecommunications industry may prove to be truly "natural" monopolies, or to be dominated for some time by a single firm, over a given range of geography. Yet even under those circumstances, there can be room for substantial improvement in the regulatory environment. The FCC and many states, for example, are beginning to gain experience with limited forms of incentive regulation that avoid the perverse incentives that can arise from traditional rate-of-return regulation. These new forms of regulation are premised on the continued existence of market power by a dominant service provider.

To an increasing extent, however, it is becoming difficult to find the true locus of monopoly power in many dominant firms. For local exchange telephone companies, industry experts had long assumed that the last bastion of natural monopoly would be the so-called local loop—the wire leading from the customer's premises to the nearest telephone switching office. Yet many of the functions of local loop service can increasingly be provided by competitive carriers for some customers. In such cases, a well-constructed regulatory environment could create a seed bed for growing competition.

The evolving telecommunications infrastructure can accelerate economic development and improve the quality of life for all Americans through the delivery of health, education, entertainment, and other needed services. Government can best help to make that happen, not by mandating its own blueprint for progress, but by serving as an intelligent referee in a highly competitive contest among industry participants. Competition in an open marketplace is the best guarantor of quality, diversity, and affordability. Where competition is not feasible, regulators should provide incentives that simulate the effects of competitive conditions to the maximum extent feasible. In most cases, reliance on the marketplace or effective market surrogates will achieve far more than top-down decisionmaking by even the most enlightened government officials.[2]

II. OVERVIEW OF THE REPORT

As noted above, this report completes a comprehensive review of the U.S. telecommunications industry. In it, we offer a broad assessment of the role of telecommunications in U.S. economic and social life, the state of the U.S. telecommunications infrastructure, and the policy prescriptions that can best promote its usefulness to the American public. These analyses are informed by several fundamental principles.

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[2] We recognize, in the following discussion, that there may be service or geographic markets where competition develops slowly. In such markets, NTIA would, of course, expect policymakers to tailor the degree and type of regulation to meet specific situations, just as it is incumbent on regulators to fashion policies that suit areas where competition is more robust.

First, government policy should seek to foster competitive markets to ensure that telecommunications infrastructure development enhances the economic, social, and personal well-being of all U.S. citizens. Experience has shown that the best way to achieve that result is to ensure that users will have access to a wide variety of services offered by competing providers. Although we recognize that a variety of services and service providers can create costs, especially through issues of standardization and interoperability, policymakers and industry can resolve these issues without sacrificing the accompanying benefits.

Second, as a rule, consumer choice in telecommunications can best be promoted through reliance on the interplay of market forces. Government's role in this process is essentially two-fold. First, it should move aggressively to eliminate government policies that are inhibiting—in some cases flatly preventing—the development of competitive telecommunications markets. Secondly, it should identify instances in which market forces will not work properly and then make necessary adjustments. But even in these areas, instead of attempting to micro-manage results, government should create incentives for efficient behavior by regulated firms.[3] In the end, infrastructure development will be promoted if private firms are allowed to make investments with the opportunity to reap rewards when they offer desired services at reasonable rates, and suffer losses when they do not.

Third, and finally, although government should focus on enabling the market to operate efficiently, it must address equity concerns. Market forces can generally be relied upon to make desired services widely available at reasonable prices, and to do so more effectively and efficiently than the welter of detailed government regulations that have traditionally been imposed on the telecommunications industry. In our view, the efficiency/equity trade-off has been substantially overstated in telecommunications policy debates. In fact, the two goals are largely complementary: the promotion of competition and the removal of unnecessary regulations generally benefit the small business and residential customer, as well as the large corporation. Moreover, even when corrective government action is deemed necessary to promote general social policy objectives (*e.g.*, by ensuring that telephone service is accessible and affordable for all citizens), government should promote "efficient equity"—that is, it should pursue solutions that achieve equity goals with the smallest loss in economic efficiency.

The U.S. communications infrastructure includes the facilities used for telecommunications, mass media, and such services as air traffic control, navigation, and public safety.

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[3] *See* Council of Economic Advisers, *The Annual Report of the Council of Economic Advisers*, H.R. Doc. 102-2, 102d Cong., 1st Sess. 29 (1991) (*CEA Report*).

In this report, NTIA focuses on telecommunications facilities, in order to conduct a comprehensive review of the complex regulatory and policy issues associated with this heavily regulated market segment.

Telecommunications can contribute to the well-being of the United States and its citizens in many ways. U.S. businesses can employ telecommunications to operate more efficiently, better serve their customers, and compete more effectively in a global economy. Social services organizations can use telecommunications to deliver critical services such as education and health care more cheaply, more extensively, and more equitably. Ordinary people can rely on telecommunications to enrich their lives through increased opportunities in both work and recreation, as well as to communicate with friends and family more easily and effectively. And millions of disabled Americans can use telecommunications to gain access to economic and social opportunities that many of their fellow citizens take for granted.

Public and private telecommunications networks have been evolving dramatically on both a national and global scale over the last several decades. Because industry participants continually adopt technical advances in shaping services to meet market demand, the mix of equipment currently employed in domestic networks reflects diverse and evolving technologies. The report recommends that the FCC as the independent federal regulatory agency, and NTIA as the Executive branch technical and policy agency, take an active role in monitoring, and when necessary, promoting, organizing, or guiding standards development.

Because different countries have different economic and social characteristics, international comparisons of infrastructure development should properly be viewed as imperfect indicia of performance. Nevertheless, such comparisons can serve as valuable points of reference for evaluating the progress of the United States in developing its infrastructure. Tables 1.1, 1.2, and 1.3 present several benchmarks relating to public telecommunications investment, penetration, utilization, and technology deployment. Our comparative analysis of several investment and technological measurements for the seven largest countries (based on national income) confirms the notion, widely expressed in the comments, that the United States is a nation with an advanced telecommunications infrastructure, characterized by a very high access-line density, a robust level of telephone usage, and a heavy emphasis on modernization (Table 1.1). The analysis also indicates that by 1994, U.S. deployment levels could trail at least some of the other "Group of Seven" nations in some areas, if these projections are correct (Tables 1.2 and 1.3). However, there is a great deal of uncertainty in the 1994 projections.

Table 1.1

Group of Seven Telecommunications Investment

	United States	Japan	West Germany	France	Italy	United Kingdom	Canada
1980-89 Avg. Annual Capital Investment per Main Line for Modernization (a)	$183.03	$174.42	$219.17	$137.17	$171.63	$89.81	$162.89
1980-89 Average Percentage of Total Invest. in Modernization	86.6%	84.1%	84.5%	67.5%	73.5%	65.8%	79.1%
1989 Network Utilization: Average Total Calls per Access Line	3,516 (b)	1,307	1,072	874	1,060	2,002	1,405
1989 Telephone Lines per 100 Population	49.0	42.2	46.3	45.2	34.9	41.4	53.4

(a) Adjusted for CPE, excluding land and building

(b) Estimated by reporting country

Source: AT&T, FCC, ITU, OECD

Table 1.2

Group of Seven Telecommunications Deployment

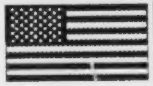
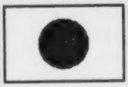
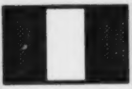
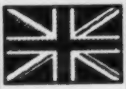
	United States	Japan	West Germany	France	Italy	United Kingdom	Canada
1989 Percentage of Digital Switches by Subscriber Lines	42.5%	31.0%	2.6%	70.7%	16.1%	38.0%	51.4%
1989 Percentage of Electronic Switches by Subscriber Lines	96.6%	44.8%	44.8%	75.9%	17.6%	23.5%	57.9%
1989 Fiber Route Kilometers per 1,000 population	1.27	N/A	0.31	1.58	N/A	N/A	2.78
1989 Percentage of ISDN Coverage by Equipped Access Line	.1%	69.0%	N/A	100.0% (a)	N/A	N/A	N/A
1989 Percentage of Offices with SS7 Capability	6.3%	N/A	N/A	47.6%	N/A	6.2%	8.4%

(a) 1990 Estimate

Source: AT&T, BT, DBP Telekom, FCC, FT, MESA

Table 1.3

Group of Seven Future Telecommunications Deployment

		 United States	 Japan	 West Germany	 France	 Italy	 United Kingdom	 Canada
Percentage of Digital Switches by Subscriber Lines	(a) 1994	68.2%	76.0%	38.0%	86.5%	N/A	92.0%	87.5%
	1989	42.5%	31.0%	2.6%	70.7%	16.1%	38.0%	51.4%
Percentage of Electronic Switches by Central Offices	(a) 1994	98.2%	93.0%	N/A	98.7%	N/A	92.0%	96.3%
	1989	92.6%	52.7%	2.8%	84.6%	17.6%	59.5%	68.5%
Percentage of ISDN Coverage by Equipped Access Line	(a) 1994	49.8%	100.0%	100.0%	100.0%	N/A	N/A	N/A
	1989	.1%	69.0%	N/A	100.0% (b)	N/A	N/A	N/A
Percentage of Offices with SS7 Capability	(a) 1994	57.0%	N/A	N/A	100.0%	N/A	83.0%	60.2%
	1989	6.3%	N/A	N/A	47.6%	N/A	6.2%	8.4%

(a) 1994 figures are industry estimates from a variety of sources, including Wallace and CC Docket No. 89-624 (Feb. 1990)

(b) 1990 Estimate

Source: AT&T, BT, DBP Telekom, FCC, FT, MESA

As we have noted, efficient investment in the infrastructure can be improved through increased competition in telecommunications markets. Accordingly, NTIA makes policy recommendations on infrastructure development with respect to customer premises equipment, interexchange service, and local exchange service, with a principal focus on eliminating or reforming those government policies that appear to be imposing uneconomic distortions on infrastructure-related investment decisions. In particular, NTIA strongly advocates increased competition in local exchange markets, and describes interconnection policies designed to promote such competition. Where full competition is not feasible (at least in the short term), we discuss the importance of regulatory approaches that replicate, to the extent possible, the incentives for efficient operation and investment that characterize competitive markets. We also favor the elimination of government-imposed barriers to competition, such as the manufacturing and information services restrictions in the AT&T Consent Decree, and the cable/telco crossownership prohibition.

Finally, NTIA outlines a new vision for universal services that has as a goal the universal availability of advanced features, on an optional, low-cost basis, throughout the United States. This proposal—Advanced Universal Service Access (Advanced USA)—would rely on the widespread introduction of local exchange competition to lower the costs and increase the availability of advanced telephone services. Moreover, it would change the current system of pricing for telecommunications services, in which the rates set by the telephone companies have the effect of subsidizing broad classes of users in a wasteful way. Instead, Advanced USA would require pricing more closely related to costs, while using targeted "subsidies" (*e.g.*, non-cost-based rates) only for those who are most in need of assistance in obtaining telecommunications services. This combination of competition and narrowly-focused, explicit subsidies would represent a significant improvement on both efficiency and equity grounds over the system of regulated monopoly and complex, unfocused cross-subsidies that currently characterizes certain parts of the local exchange market.

Chapter 2

The Infrastructure

In its most general sense, the term "infrastructure" refers to a nation's stock of physical capital that provides the underlying foundation or framework for private-sector endeavors, or that is used to furnish essential services to the public.[4] As such, the term encompasses both the capital owned or funded by government (*e.g.*, highways and airports) and the capital assets controlled by private firms subject to varying levels of government oversight (*e.g.*, railroads and electric companies).

It is also useful to distinguish among different types of "infrastructure," depending on the purposes for which capital investments are used. Thus, people commonly speak of a "transportation infrastructure" composed of the highways, railways, waterways, and airports that facilitate the movement of vehicles, passengers, and commodities from place to place. Similarly vast infrastructures are in place to furnish electricity, water, gas, and sewage disposal services to homes and businesses.

The United States also possesses an extensive and well-developed communications infrastructure which, broadly speaking, encompasses all of the facilities and instrumentalities engaged in delivering and disseminating information throughout the nation. This infrastructure, of course, includes the facilities employed to convey information by wire and radio, such as those used for telecommunications (*e.g.*, telephony), and mass media services (*e.g.*, broadcasting and traditional cable television service). However, the U.S. communications infrastructure also includes the facilities of the Postal Service, Western Union, and the express firms that deliver letters, telegrams, and packages across the country and around the world. It embraces the publishing and printing facilities that produce the myriad books, newspapers, magazines, and other periodicals that comprise the vibrant print media. It includes the production and distribution systems of the motion picture industry, which create and distribute ideas and entertainment to the American public via films, television, and video cassettes.

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[4] *See* Notice, 55 Fed. Reg. at 801, para. 5 (quoting Fox, *Public Infrastructure and Economic Development*, in U. S. Dep't of Agriculture, *Rural Economic Development in the 1980s: Prospects for the Future*, Research Report No. 69, at 282 (Sept. 1988)); Bourque, *The Infrastructure Gap*, Growth and Change, at 17 (Jan. 1985). *See also* J. Gwartney & R. Stroup, *Economics: Private and Public Choice* 768 (4th ed. 1987) ("infrastructure" refers to the "provision of a legal, monetary, educational, transportation, and communication structure necessary for efficient operation of an exchange economy"); Comments of Washington UTC at 1 ("infrastructure" is "the capital assets of a country available for public use") (quoting *A Dictionary of Economics and Business* (1985)).

This report addresses one major segment of the communications infrastructure—telecommunications facilities, by which we mean facilities that permit point-to-point,[5] two-way transmission of information of the user's choosing. Further, as indicated in the Notice, this report does not focus on other major segments of the U.S. communications infrastructure, including that used to provide mass media services.[6] NTIA's decision to limit this study in this fashion elicited criticism from some commenting parties, especially broadcasting interests.[7] Their critiques center on two essential points. First, some commenters contend that NTIA's decision to exclude mass media services from our definition of "telecommunications" is in error.[8] These parties suggest, in effect, that it is inappropriate to distinguish between telecommunications and mass media services. Second, commenters argue that even if such a distinction is proper, it is incorrect or short-sighted to focus only on telecommunications.[9]

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[5] *See* Modification of Final Judgment, *United States v. AT&T,* 552 F. Supp. 131, 229 (D.D.C. 1982), *aff'd sub nom. Maryland v. United States,* 460 U.S. 1001 (1983) (telecommunications means "the transmission, between or among points specified by the user, of information of the user's choosing"); W. Sharkey, *The Theory of Natural Monopoly* 182 (1982) ("reasonably broad definition of the telecommunications industry is that it provides for electronic, point-to-point communication needs among groups of people or machines"); Comments of United Telecommunications, Inc. at 2 ("telecommunications infrastructure consists of the facilities that enable voice, data, video or other communications to be transmitted from one point to another").

This commonly-used description of "telecommunications" is not entirely satisfactory, because not all telecommunications transmissions are truly "point-to-point," in the sense that they involve only two locations. In fact, some (*e.g.*, electronic mail) may be point-to-multipoint in character; others (*e.g.*, a telephone conference call) may be multipoint-to-multipoint in nature. However, in one fundamental respect, the term "point-to-point" is a useful way of distinguishing telecommunications transmissions from other radio or wire communications. When people make such transmissions (say, a telephone call), they know that their messages will be sent only to those locations they have designated (by the digits that they have dialed or the instructions that they have given to the operator), and to no one else. It is this highly "addressed" or "directed" feature that distinguishes telecommunications transmissions from mass media communications, which are usually transmitted in a way that does not permit the sender to know who is receiving the message. Because the term "point-to-point" suggests the "addressed" or "directed" characteristic of telecommunications transmissions, it has proven to be a useful, short-hand way of describing telecommunications.

[6] *See* Notice, 55 Fed. Reg. at 805 n.59, para. 40. While the Notice did not fully explain what NTIA meant by "mass media services," such services clearly include radio and television broadcasting. We also use the term to include cable television, although that classification is complicated by the fact that some cable television systems have used their facilities to provide telecommunications services for a number of years. *See* National Telecommunications and Information Administration, U.S. Dep't of Commerce, *Competition in the Local Exchange Telephone Service Market,* NTIA Report 87-210, at 38-39 (Feb. 1987) (*Local Exchange Competition*). This activity may grow if regulators were to remove existing legal barriers to competitive provisioning of local telecommunications services by cable systems. However, the core of the cable television business is and, for the near future, will likely remain the transmission of broadcast-like video services.

[7] *See, e.g.,* Comments of INTV at 2; Comments of Cox Enterprises, Inc. at 3; Comments of NAPTS/PBS at 4; Comments of NAB at 2; Comments of CPB at 21. *See also* Comments of Ameritech at 4-5; Comments of the State of Minnesota at 1; Comments of Francis Dummer Fisher at 1-2.

At first blush, the distinction in the Notice between telecommunications and mass media services appears anachronistic, given the often remarked-upon convergence of the telecommunications and mass media industries.[10] That convergence is certainly occurring, as similar facilities and technologies increasingly can be used to provide both mass media and telecommunications services. For example, development and deployment of high capacity, broadband facilities by telecommunications firms, coupled with continuing growth in the capacity of their existing facilities, has raised the prospect that such firms will soon be able to offer video services that traditionally have been the province of mass media companies. On the other hand, the cable industry has long had the capability to offer both conventional mass media services and telecommunications services.[11] That capability can only increase as cable systems upgrade their networks in the coming years. In addition, television and radio stations can now provide telecommunications services, such as data transmission and paging, via unused portions of their assigned broadcast frequencies.[12]

In preparing this report, we were, of course, aware of these developments. Nevertheless, our decision to continue to distinguish between mass media and telecommunications services, and to concentrate on telecommunications in this report, was based on both practical and policy considerations.[13] First, the range and complexity of communications issues (mass media and telecommunications alike) are such that if we did not attempt to limit the current study in some fashion, we could not have brought it to a satisfactory conclusion.[14]

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[8] *See, e.g.*, Comments of INTV at 2; Comments of NAPTS/PBS at 4.

[9] *See, e.g.*, Comments of NAB at 2-5; Comments of Cox Enterprises, Inc. at 3.

[10] *See, e.g.*, Comments of MIT Media Laboratory at 10-11.

[11] *See Section 214 Certificates*, 21 FCC 2d 307, 324-25 (1970); *Local Exchange Competition, supra* note 6, at 38-39.

[12] *See Amendment of Parts 2, 73, and 76 of the Commission's Rules to Authorize the Offering of Data Transmission Service on the Vertical Blanking Interval by TV Stations*, 101 FCC 2d 973, *recon. denied*, FCC 85-360 (released July 9, 1985); *Amendment of Parts 2, 73 and 76 of the Commission's Rules to Authorize the Transmission of Teletext by TV Stations*, 48 Fed. Reg. 27,054 (1983), *recon.*, 101 FCC 2d 827 (1985), *rev'd in part sub nom. Telecommunications Research and Action Center v. FCC*, 801 F.2d 501 (D.C. Cir. 1986); *Amendment of Parts 2 and 73 of the Commission's Rules Concerning Use of Subsidiary Communications Authorizations*, 48 Fed. Reg. 28,445 (1983), *recon. denied*, 49 Fed. Reg. 19,659 (1984).

[13] One commenter expresses concern that this decision may signal NTIA's support for a "wire-based" or, even, a "one wire"-based solution to the nation's communications and information-distribution needs. *See* Comments of NAB at 19. This is erroneous. We consider a number of wireless transmission technologies (continued...)

Second, and more importantly, our decision was prompted by the different regulatory and market environments surrounding the mass media and telecommunications industries. Much of the mass media marketplace is characterized by competition, both among different mass media services and between the mass media industry and the print and film industries. Further, state agencies have no regulatory authority over radio and television broadcasting,[15] and their authority over cable television is circumscribed by the Cable Communications Act of 1984 (the Cable Act)[16] and FCC decisions. Moreover, over the years, the FCC has either removed or substantially relaxed its regulation of both broadcasting and cable.[17]

In contrast, in major segments of the telecommunications industry, particularly local exchange service markets, competition is either non-existent or not well-established. Further, as noted below, many telecommunications firms are subject to pervasive regulation at both state and federal levels. Because telecommunications is, on the whole, less competitive and more heavily regulated than mass media, and because NTIA believes that the absence of competition and the presence of government regulation affect infrastructure development, we decided that the best use of our limited resources for this report would be a thorough review of the telecommunications portion of the communications infrastructure.[18]

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[13] (...continued from preceeding page)
in this report, including cellular radio, terrestrial microwave, and satellite. Moreover, in a recent report, NTIA stressed the critical importance of spectrum-based communications technologies to the U.S. economy. *See* National Telecommunications and Information Administration, U.S. Dep't of Commerce, *U.S. Spectrum Management Policy: Agenda for the Future*, NTIA Special Pub. 91-23, at 1, 13-14 (Feb. 1991) (*Spectrum Report*).

[14] We note that this "limited" inquiry into telecommunications infrastructure issues elicited some 10,000 pages of public comments.

[15] *See Allen B. Dumont Laboratories v. Carroll*, 184 F.2d 153 (3d Cir. 1950), *cert. denied*, 340 U.S. 929 (1951) (Communications Act preempts state regulation of radio and television broadcasting).

[16] Pub. L. No. 98-549, 98 Stat. 2780, codified at 47 U.S.C. §§ 521-559 (1988).

[17] *See, e.g.*, National Telecommunications and Information Administration, U.S. Dep't of Commerce, *NTIA Telecom 2000: Charting the Course for a New Century*, NTIA Special Pub. 88-21, at 488, 519-520, 548-549 (Oct. 1988) (*Telecom 2000*).

[18] Of course, the telecommunications focus of this report does not reflect a lack of interest or concern in mass media issues. In addition to the major report on radio frequency spectrum mentioned in note 13 above, we are now conducting a separate proceeding on the globalization of the mass media industry and its implications for U.S. mass media policies.

Having limited the current study to the telecommunications portion of the communications infrastructure, this report will concentrate on facilities and serving arrangements that are being used or can be used to provide point-to-point communications.[19] As suggested in the Notice, this approach clearly includes the public switched networks offered by LECs, like the Bell Operating Companies (BOCs) and the many "independent" telephone companies.[20] It also subsumes the public long distance networks operated by facilities-based carriers, such as AT&T, MCI, and US Sprint.

Furthermore, we concur with those observers who assert that the telecommunications infrastructure encompasses the many other facilities that are commonly employed to satisfy users' telecommunications needs.[21] Such facilities include those offered by metropolitan area networks (MANs), local area networks (LANs), value-added networks (VANs), teleports, cellular radio systems, shared tenant services (STS), satellite carriers, and many private networks.[22] The term would also include transmission systems that are still being developed, such as radio-based personal communications services (PCS), once they have been deployed. Finally, we define the telecommunications infrastructure to encompass the various types of terminal equipment, or customer premises equipment (CPE), that enable users to originate and terminate communications.[23] One cannot get an accurate picture of the quality and capabilities of the domestic telecommunications system without considering these many alternatives and supplements to the public switched networks offered by the traditional telephone common carriers.

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[19] Although this report focuses primarily on the development of telecommunications facilities, networks, and services, we do not examine in detail important "information issues," such as customer privacy, network security, and consumer fraud using telecommunications. We note, however, that these matters are being addressed by a number of other bodies, including government agencies. *See, e.g.*, United States Office of Consumer Affairs, *Telephone Transaction Generated Information Principles*.

Moreover, although the principal focus of this report is on telecommunications, there is some overlap with specific mass media issues, such as the potential for competition to cable operators from local exchange carriers (LECs). Similarly, in examining the use of telecommunications in education, we acknowledge the long-time role of educational broadcasting. We address such issues in a limited context, *i.e.*, their relationship to traditional "telecommunications" providers.

[20] Notice, 55 Fed. Reg. at 801, para. 6.

[21] *See, e.g.*, Comments of Ameritech at 4-5; Comments of United Telecommunications, Inc. at 2-3; Comments of PacTel at 7-10; Comments of Siemens Corp. at 6-7; Comments of APC at 2; Comments of API at 7; Comments of CCTU at 12-15; Comments of Eastman Kodak Co. at 3.

[22] Of course, the infrastructure also encompasses cable television systems and broadcasting stations to the extent that such systems provide point-to-point communications. See *supra* note 6 and notes 11 and 12, and accompanying text.

[23] *See* Comments of IDCMA at 5-6; Comments of NATA at 3-4; Comments of Siemens Corp. at 6.

This report will address issues that affect all firms encompassed within this broad definition of telecommunications, especially those parts of the U.S. telecommunications system that remain subject to entry or rate regulation by federal or state governments. For example, although both the CPE and interexchange services markets are characterized by vigorous competition and reduced regulation, important infrastructure issues remain in both areas, including whether the BOCs should be able to manufacture CPE and whether the FCC should reduce its regulation of AT&T.

However, because regulation is most extensive with respect to local telecommunications facilities and services, it is logical to address that part of the domestic telecommunications system to determine the effects of government regulation on its development. The FCC and state public utility commissions closely regulate many of the LECs' activities, including their pricing and investment decisions. Moreover, although the firms that furnish alternative local services (*e.g.*, MANs, LANs, teleports, STS operators, mobile radio providers, such as cellular radio firms) are generally not subject to comprehensive federal or state rate regulation, they are subject to considerable entry regulation. For example, state regulations often limit the types of services those firms can offer in competition with LECs. Similarly, the FCC's decision to allocate radio spectrum to only two cellular radio systems per geographic market limits entry by competing facilities-based cellular radio providers. Because such government entry regulations can directly affect investment and, thus, infrastructure development, we discuss them in this report.

Finally, universal service concerns also prompt us to focus on the local facilities and services associated with the public switched networks operated by the LECs. As many commenters noted, such offerings pose unique issues because most users, particularly residential and small business customers, have virtually no alternative to the LEC public switched networks to satisfy their telecommunications needs.[24] If these users are to share in the benefits that telecommunications can produce, the public networks on which they rely must be able to provide the services and capabilities that make such benefits available.

We wish to make clear, however, that our approach in no way reflects a preference for policies that would promote public switched network development by artificially handicapping or restricting investment in private networks or any other portion of the telecommunications infrastructure. As noted in Chapter 1, our fundamental objectives are to identify equitable policies that will assure users of a diversity of services and sufficient providers to meet their communications needs, through competition when possible. We believe that achievement of these goals requires efficient deployment of advanced local public switched networks—the telecommunications facilities upon which most users, and especially residential users, rely—as well as other portions of the telecommunications infrastructure. We are also convinced that policies promoting efficient infrastructure development will permit entrepreneurs and users to expand the U.S. telecommunications system to meet consumer needs.

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[24] *See, e.g.*, Comments of Ameritech at 15-17; Comments of NYNEX Corp. at 8; Comments of Rochester Telephone Co. at 7-9, 16-19; Comments of TDS at 9-12; Comments of Northern Telecom at 9; Comments of CCTU at 13-14; Comments of Washington UTC at 2-3.

Chapter 3 Importance of Infrastructure

I. INTRODUCTION

Telecommunications is a vital component of the U.S. economy and, indeed, of the nation's way of life. Rapid and efficient communication—initially by telegraph, and later by telephone—was important in the nineteenth century in unifying the country as the United States expanded westward and developed into an industrial power. As economic markets became more and more globalized, America's domestic communications system was important in permitting U.S.-based firms to operate efficiently and to compete internationally. Finally, even the most casual telephone user cannot but marvel at the ease and simplicity with which he or she can communicate, using either voice or data, with others in other parts of the country or the world.

Virtually all commenters agreed that the telecommunications portion of the U.S. communication infrastructure "will play a critical role in improving the domestic economy of the United States, the welfare of its people, and its ability to remain competitive in the global marketplace of today and tomorrow."[25] Several parties repeated the oft-stated analogy that telecommunications facilities and services will be as important to the future performance of the U.S. economy as transportation systems have been in the past.[26]

In the balance of this chapter, NTIA will examine ways in which telecommunications contributes to the improved performance of the U.S. economy and the enhanced welfare of the American people. Specifically, we will explore how businesses are using telecommunications to reduce costs, increase efficiency, and better serve their customers;

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[25] Reply Comments of BellSouth Corp. at 2. *See also* Comments of USTA at 11; Comments of IDCMA at 10; Comments of Siemens Corp. at 8; Comments of SBA at 1; Comments of Eastman Kodak Co. at 4; Supplemental Comments of ICA at 3.

[26] *See* Comments of LMDDC at 11; Comments of NGA at 1. *See also* Notice, 55 Fed. Reg. at 800, para. 2 (citing D. Marchand and F. Horton, *InfoTrends: Profiting from Your Information Resources* 29 (1988)).

how the availability of adequate telecommunications facilities and services can influence economic development; and how telecommunications can improve delivery of critical services and enhance the quality of life in the United States.

In subsequent chapters, we will consider whether the domestic telecommunications infrastructure, as it is and as it is evolving, will be sufficiently developed to allow U.S. business and citizens to reap the full potential of telecommunications. The current chapter provides the factual predicate for the discussion in those latter chapters. Speaking plainly, it attempts to show why the public and policymakers other than telecommunications specialists should care about telecommunications issues at all.

II. TELECOMMUNICATIONS AS A FACTOR OF PRODUCTION

In the past three decades, U.S. firms have expanded the role of telecommunications in their market activities.[27] One study submitted in this inquiry by Data Resources/McGraw-Hill (DRI) indicates that the average domestic industry increased its rate of telecommunications consumption by more than 167 percent between 1963 and 1982.[28] Another study, by National Economic Research Associates, Inc. (NERA), states that usage of telecommunications by the U.S. economy as a whole rose by some 75 percent between 1977 and 1985.[29]

This increased reliance on telecommunications is also reflected, at least in part, in the steady rise in telephone traffic in recent years. For example, the volume of calling in the United States grew some 42 percent between 1980 and 1989, from 866 billion minutes of use to 1.23 trillion minutes of use.[30] This growth was fueled primarily by increases in intrastate and interstate toll calling, which rose 104 percent and 159 percent, respectively, over that period.[31] However, local calling also grew by some 25 percent over that ten year period, from 729 billion minutes of use to 915 billion minutes of use.[32] The rapid expansion in interstate toll calling between 1984 and 1989 reflects, to a large extent, the fact that interstate long distance rates for the average residential customer declined almost 45 percent over that period,[33] due in large part to repricing of interstate services by the FCC in its access charge proceedings[34] and the growth of competition in the long-distance market.

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[27] *See* Deloitte & Touche, *New Jersey Telecommunications Infrastructure Study,* Vol. II, at V-28 to V-30 (Jan. 1991) (*Deloitte and Touche Study*).

[28] Data Resources/McGraw-Hill, *The Contribution of Telecommunications Infrastructure to Aggregate and Sectoral Efficiency* i, vii, 15 (Feb. 1991) (*DRI Study*) (submitted on behalf of Ameritech, Bell Atlantic, BellSouth, Cincinnati Bell, the GTE telephone companies, NYNEX, Pacific Bell, Southern New England Telephone, Southwestern Bell, United Telephone, and US West). Some industries increased their use of telecommunications by more than 800 percent. *See id.* at i, vii, 31.

[29] National Economic Research Associates, Inc., *Telecommunications Infrastructure, Productivity, and Economic Development* 15-16 (Apr. 1990) (*NERA Study*) (submitted as App. 1 to Comments of USTA). The apparent discrepancy in the growth figures appearing in the two studies is a function of the time periods considered and different measurements of telecommunications usage. DRI measures an industry's consumption of telecommunications as a percentage of all inputs used by that industry. *DRI Study, supra* note 28, at vii. NERA defines "telecommunications intensity" as the ratio of an industry's telecommunications services and equipment purchases to total industry output. *NERA Study* at 16.

Although much of this increased telecommunications usage was concentrated in growing service industries,[35] virtually every other sector of the economy also expanded its consumption of telecommunications,[36] as more and more firms began to view telecommunications as a means of gaining and sustaining a competitive advantage over their domestic and foreign rivals.[37] Moreover, residential customers also greatly increased their consumption of telecommunications services and products.

A. USE OF TELECOMMUNICATIONS IN VARIOUS INDUSTRIES

The record in this proceeding provides numerous examples of the growing importance of telecommunications to American businesses. This anecdotal evidence is illuminating in at least two respects. First, it highlights the many ways in which telecommunications can assist firms in developing, producing, and marketing their goods and services. Second, it shows that the potential benefits of telecommunications are exploitable by firms of all sizes and in all industries.

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[30] *See* Industry Analysis Division, Common Carrier Bureau, Federal Communications Commission, *Trends in Telephone Service* at 26, Table 18 (released Aug. 7, 1991) (*Telephone Trends*). The FCC's data on local calling were expressed in Dial Equipment Minutes (DEMs). Because two DEMs are counted for each minute of conversation, *see id.* at 25, we have divided the values listed in Table 18 by two to derive minutes of use for the period 1980-1989.

[31] Intrastate toll minutes of use went from 71 million in 1980 to 144 million in 1989, while interstate toll minutes of use increased from 67 million to 177 million. *See id.* at 26, Table 18. By 1989, 14 percent of all usage was attributable to interstate long distance calls, up from 8 percent in 1980. *See id.* at 25.

[32] *See id.*

[33] *See id.* at 12.

[34] *See MTS & WATS Market Structure*, 93 FCC 2d 241, *recon.*, 48 Fed. Reg. 42,984 (1983), *further recon.*, 49 Fed. Reg. 7,810, *aff'd in relevant part sub nom.*, *National Ass'n of Reg. Util. Comm'rs v. FCC*, 737 F.2d 1095 (D.C. Cir 1984), *cert. denied*, 469 U.S. 1227 (1985).

[35] *See DRI Study*, *supra* note 28, at vii, 31; *NERA Study*, *supra* note 29, at 16.

[36] *See DRI Study*, *supra* note 28, at 29-31; *NERA Study*, *supra* note 29, at 15-16 and App. C and D.

[37] *See* Bell Communications Research, *Telecommunications Infrastructure: Analysis of its Economic Impacts* at 9 (Apr. 1990) (*Bellcore Study*) (submitted as Attach. 1 to Joint Comments of Bellcore).

1. Service Firms

For many consumers, the increased usage of telecommunications by service firms is typified by automatic teller machines (ATMs) and point-of-sale (POS) terminals. ATMs allow customers to complete a wide range of banking transactions, day or night, without setting foot inside a bank. Today, there are more than 75,000 ATMs in the United States, handling over 400 million transactions per month.[38] For the banks, the cost of an ATM transaction is about one-half that of a transaction handled by a teller.[39] ATMs also reduce the number of tellers needed to service customer accounts by reducing the account load per teller.[40] The benefits for bank customers are obvious. Indeed, many banks that did not invest in ATM technology in the early 1980s are now losing customers to financial institutions that did.[41]

POS devices allow retailers to transmit sale information and the customer's credit card number to a central processing site via telecommunications for validation and authorization.[42] One organization estimates that, by the end of 1990, there were more than 53,000 POS terminals in use, processing some 12.4 million transactions every month.[43] Although retailers first established POS networks to speed processing of credit card transactions and to reduce the time lag between sale and receipt of payment, such networks also protect retailers against losses from bad checks and credit cards.[44] More complex POS devices also enable retailers to keep constant track of sales and inventories by product categories. In turn, this enables the firms to reduce the overall size of their inventories and respond more rapidly to shifting consumer demand.

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[38] *See NERA Study, supra* note 29, at 10.

[39] *See Telecom 2000, supra* note 17, at 450.

[40] *See id.*

[41] *See* Reply Comments of FMR Corp. at 2.

[42] In many cases, the approved transaction will then appear on the customer's next credit card bill. Increasingly, however, POS devices are configured so that the sale price can be deducted directly from the customer's bank account, in essence allowing the customer to write "electronic checks." *See NERA Study, supra* note 29, at 10.

[43] Source: Electronic Funds Transfer Ass'n.

[44] *See Telecom 2000, supra* note 17, at 443, 445, 451.

Electronic data interchange (EDI) systems complement POS devices by furnishing a telecommunications-based substitute for business documents. With POS devices providing information that engenders more frequent purchase orders by retailers and others in the distribution chain, EDI can facilitate such transactions either on a people-assisted or, in some cases, fully automatic basis.

SuperValu, a grocery wholesaler located in Eden Prairie, Minnesota, uses EDI for 50-80 percent of its purchase orders, thereby enabling it to save nearly $1.5 million annually.[45] Foremost McKesson, a pharmaceutical distributor, uses the public switched network to expedite delivery of orders to retailers. Retailers mechanically scan the tags of the products they wish to order, then plug the scanner into a phone jack. The information is then transmitted via phone lines to Foremost McKesson's central computer, which determines how the orders should be packaged and shipped in the most efficient manner.[46] POS systems can also be programmed to deduce when shelf supplies are becoming depleted and generate EDI requests automatically. According to Arthur Andersen & Company, a system that links retailers with apparel and textile manufacturers by integrating POS devices with an EDI network has produced $9.6 billion worth of benefits for 75 clothing retailers in less than three years.[47]

While EDI can help merchants avoid going too far out on a limb when projecting market demand, it is no substitute for the intuitive feel for customer preferences that retailers can develop when dealing with the public on a day-to-day basis. The JC Penney Co. exploits that kind of knowledge by employing video conferencing to permit joint viewing and discussion of new products with potential buyers. This has enabled Penney's to save $500,000 per year in travel costs, reduce product sample costs by some $4 million annually, and stay in closer touch with customer demand.[48]

Other telecommunications applications enable consumers to bypass local retailers altogether. One of the best known examples is L.L. Bean, a clothing and outdoor sporting company located in Freeport, Maine. In 1965, Bean sold most of its goods from its Freeport store and through conventional catalog sales. At that time, telephone catalog sales generated about $3,000, or less than 1 percent of the company's annual sales.[49] By 1987, telephone catalog sales reached some $310 million, or roughly 68 percent of Bean's annual sales.[50] In that year, the company received in excess of 6.5 million calls for ordering, service, or special information, more than double the number received two years earlier.[51]

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[45] *See NERA Study, supra* note 29, at 27.

[46] *See id.* at 27-28.

[47] *See* A. Toffler, *PowerShift* 124-125 (1990).

[48] *See NERA Study, supra* note 29, at 13.

Other service firms are employing telecommunications in ways that are less visible to the consumer, but no less important to the firms. Mrs. Fields' Cookies, a company with annual sales of $100 million, uses a satellite-based telecommunications system to link 500 stores in the United States and five other countries with the company's headquarters in Park City, Utah.[52] In addition to monitoring hour-to-hour sales levels at each store, the network gives each store manager immediate access to the company's chief executive officer via voice communication or electronic mail.

Anichini Linea Casa uses telecommunications to import and distribute fine Italian linens from the small town of Tunbridge, Vermont.[53] The company uses traditional telephone service, telex, facsimile, and computer transmission to place orders with suppliers in Italy and to respond to requests from retail outlets in the United States.[54] Founded in 1985 with two employees, Linea Casa now employs 11 people, and has annual sales in excess of $3 million.[55]

Edward D. Jones & Co., a financial services firm headquartered in Maryland Heights, Missouri, has invested $30 million in a two-way satellite network linking together its 1,600 retail offices in 44 states.[56] This investment was prompted by the company's desire to curb annual increases of 10-15 percent in its local and long distance telephone bills. Fully deployed in 1990, the satellite network allows brokers in each field office to place customer orders with company headquarters in seconds. It also gives brokers virtually instantaneous access to stock market information (updated seven times a day), forecasts on dividends and earnings for 1,000 companies, and live television broadcasts for product presentations and training sessions and seminars.[57] Similarly, Alex Brown and Sons, the largest brokerage firm headquartered outside of New York, uses video conferencing to inform its sales force and clients about late breaking developments that could influence stock prices.[58]

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[49] *See Deloitte and Touche Study, supra* note 27, Vol. II, at V-19.

[50] *See id.*

[51] *See id.*

[52] *See id.*, Vol. II, at V-16.

[53] *See id.*, Vol. II, at V-13; Comments of NYNEX Corp. at 13.

[54] *See* Comments of NYNEX Corp. at 13.

[55] Sales have been growing at the rate of 76 percent per year. *See id.*

[56] Davidson, Dibble, and Hom, *Telecommunications and Rural Economic Development* 7.1.1 (October 26, 1990) (*Davidson*).

2. Manufacturing Firms

Although many people intuitively recognize the importance of telecommunications to service firms, they are less aware of the fact that manufacturers are also becoming major users of telecommunications in an effort to reduce costs, control quality, and accommodate feedback from consumers. In 1984, General Motors (GM) purchased Electronic Data Systems (EDS), operator of the world's largest private telecommunications network,[59] in order to stitch together 100 separate networks connecting various GM facilities with each other and with suppliers and dealers.[60] Among other things, the EDS network has enabled GM to increase significantly the efficiency of its internal coordination and communications activities.[61] The network also allows GM and its suppliers to coordinate delivery of parts more closely with assembly plant schedules, thus reducing inventory costs and assembly line stoppages.[62]

Chrysler Corporation has used its private telecommunications network to deploy a Dynamic Inventory Analysis System, which monitors the activities of 10,000 employees, the location of some 40,000 parts, and the production of 12,000 cars daily.[63] Telecommunications also underlies Chrysler's computer integrated manufacturing system which, among other things, allows the firm to build cars to customers' orders. By using telecommunications in these and other ways, Chrysler has cut inventory costs by $700 million in 40 assembly plants and reduced paperwork by 20 percent.

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[57] *See id.* at 7.1.2-7.1.3.

[58] *See* Comments of Northern Telecom at 22.

[59] *See* Comments of Ameritech at 33.

[60] *See id.* EDS also provides GM with a substantial separate revenue stream; only about one-half of EDS' $5 billion in annual sales come from GM. *Id.*

[61] *See* Comments of Herbert Dordick at 3.

[62] *See NERA Study, supra* note 29, at 17-18.

[63] *See id.* at 18 and App. A.

Telecommunications capabilities are also critical to Nastec, a Bennington, Vermont firm that manufactures steering columns for Japanese automobiles.[64] Nastec uses the public switched network to maintain contact with buyers and parts suppliers to ensure that adequate inventories of parts and materials are on hand at the firm's manufacturing plants. Additionally, private telecommunications facilities link Nastec's engineering design offices in Connecticut with its manufacturing plants to permit transfer of essential engineering information, such as designs and specifications, among those locations.[65]

At Hewlett Packard (HP), engineers on both sides of the Atlantic can communicate via telecommunications about designs still on the drawing board within a twenty-four hour period.[66] HP also uses EDI for about 25 percent of its purchasing, enabling the firm to obtain needed materials within 5-10 days instead of 4-5 weeks. Finally, HP's ability to use telecommunications to shorten the time between product development and marketing has "revitalized the company's flagging product portfolio just in time to establish a commanding presence in the microcomputer market."[67]

Boeing uses video conferencing to link engineers scattered around the Puget Sound area, thus allowing it to expedite design of its new 757 jet airliner.[68] Another aviation firm, McDonnell-Douglas, estimates that its video conferencing network has saved the company some $4 million annually (mostly in travel expenses), even after factoring in the cost of the network.[69] The graphics capability afforded by that network also enabled McDonnell-Douglas employees to complete one project in half the expected time, because groups at different locations could see and understand co-workers' designs and proposals.[70]

Bendix King, an electronics manufacturer, used video conferencing to interconnect six sites in Olathe, Kansas, and one in Ft. Lauderdale, Florida, to bring together the design team that developed a new air traffic alert and collision avoidance system. Bendix King was the first of several competing firms to get FAA certification for its system, and the company believes that video conferencing gained its system designers a one year lead over potential competitors.[71]

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[64] *See Deloitte and Touche Study, supra* note 27, Vol. II, at V-17; Comments of NYNEX Corp. at 14.

[65] *See Deloitte and Touche Study, supra* note 27, Vol. II, at V-17.

[66] *See NERA Study, supra* note 29, at 21-22.

[67] *See id.* at 22.

[68] *See id.* at 4.

[69] *See Deloitte and Touche Study, supra* note 27, Vol. II, at V-18.

[70] *See id.*

3. Transportation Firms

Although transportation facilities such as highways and railroads are considered classic examples of U.S. infrastructure, transportation firms themselves have long been major users of telecommunications.[72] Taxicabs' reliance on radio dispatching is perhaps the application most familiar to urban dwellers. However, other types of transportation firms are continually expanding their existing communications capabilities and exploring new ways in which telecommunications can improve their economic performance. For example, the railroad industry is currently investing between $1.5 and $2 billion to construct its Advanced Train Control System, a computerized land mobile radio network that will be used to determine automatically the position of trains, control their speed and movement, operate switches, and alert dispatchers and engineers to potential safety hazards.[73] Railroads now employ extensive private telecommunications networks to speed freight bills, invoices, and other documents to shippers and suppliers, as well as to track movement of freight cars among different railroads. This latter activity alone has enabled railroads to reduce empty car miles by some 260 million miles each year, producing cost savings of about $91 million annually.[74]

Trucking companies have also been heavy users of radio dispatch services to direct and track the movement of their vehicles within a city or in the vicinity of their terminals.[75] Until recently, however, these companies had only limited ability to monitor the movements of their trucks on intercity or interstate trips.[76] Now the industry is benefiting from the development of telecommunications-based mobile data services, which permit trucking firms to determine the exact location of vehicles at every stage of their journey. By so doing, the companies can increase driver productivity, better match up empty trucks and freight pickups, and provide more detailed shipping and delivery information to their customers.[77] Some 10,000 trucks are now equipped with mobile data devices, and the number is expected to exceed 100,000 within five years.[78]

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[71] *See* Comments of Northern Telecom at 22.

[72] Although transportation firms generally are in the business of providing services, the transportation industry is commonly considered separate from other "service" industries. *See DRI Study, supra* note 28, at 16, 21 (listing transportation as an industry segment separate from "classic" service industries, such as wholesale/retail trade, finance and insurance, and personal/business services).

[73] *See* Comments of AAR at 4. Railroads have historically been major users of telecommunications in their operations. They currently operate more than 44,000 route miles of microwave facilities. *See id.* at 2.

[74] *See NERA Study, supra* note 29, at 24.

[75] *See* Comments of American Trucking Associations, Inc. in *Comprehensive Policy Review of Use and Frequency Management of the Radio Frequency Spectrum* at 9 (filed Feb. 22, 1990).

[76] Trucking firms have tried to overcome this problem via telephone calls from drivers to dispatchers, mail reports, and onboard data recording devices. *See id.* at 9-10.

Telecommunications is equally important to the airline industry. Most obviously, telecommunications facilities and services are at the heart of the nation's air traffic control system, which is crucial to the efficient and safe use of increasingly crowded airports and air space. For example, when a Mother's Day fire in 1988 destroyed a telephone switching office in Hinsdale, Illinois, air traffic control at nearby O'Hare Airport was so disrupted that 20 percent of all flights had to be canceled the next day.[79]

Telecommunications also benefits airlines in other ways. The airlines' telecommunications-based computer reservations systems now not only schedule flights and assign seats, but also indicate how many passengers are on a particular plane, whether some of them require special meals, which crew is scheduled, and what maintenance teams are needed.[80] This has helped relationships between airlines, travel agencies, and corporate travel customers.[81] Airlines have also realized significant revenues from the use of their reservation systems by travel agents and others. In 1986, for example, American Airlines' profits from its computer reservation system were nearly twice the profits of its airline operations.[82]

B. STUDIES

Although the benefits of telecommunications to U.S. businesses and to the American economy can be inferred from the foregoing examples, they are not easily quantified. The record in this proceeding contains only two studies that examine in any detail the linkage between usage of telecommunications and economic growth or productivity. One of those studies, completed by NERA and submitted to NTIA by USTA, provides data to support three fundamental propositions: (1) the U.S. industries that use telecommunications most intensely are in the service sector; (2) those telecommunications-intense industries tend to have higher employment growth than industries that use telecommunications less heavily; and (3) they also tend to have higher economic growth.[83] These assertions appear to reflect accurately the underlying data. For instance, the five U.S. industries with the largest expenditures on telecommunications (measured as a percentage of total output) are service-related.[84] The employment growth of these same five industries between 1981 and 1988 also far exceeded employment growth in manufacturing, mining, and agriculture, which are, relatively speaking, less telecommunications-intensive.[85]

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[77] *See* Moskal, *Trucking Looks to the Sky for Its Future*, Transp. and Distribution, Apr. 1989, at T14.

[78] *See* Comments of American Trucking Associations, Inc. in *Comprehensive Policy Review of Use and Frequency Management of the Radio Frequency Spectrum* at 10 (filed Feb. 22, 1990).

[79] *See* Crockett, *Fire in Illinois Bell CO Raises Recovery Concerns*, Network World, May 16, 1988, at 1.

[80] *See Bellcore Study*, *supra* note 37, at 6, 8.

[81] *See id.* at 9.

[82] *See NERA Study*, *supra* note 29, at 25.

However, the data do not establish, as NERA acknowledges, a cause and effect relationship between telecommunications usage, on the one hand, and productivity and economic growth, on the other. Although service industries tend to rely heavily on telecommunications, such reliance may not explain the employment and economic growth exhibited by those industries in the period NERA considered (*i.e.*, 1977-85). For example, the increase in employment in telecommunications-intensive service industries may also reflect increased demand for services and the expanded role that service industries now play in the U.S. economy.[86] Similarly, the NERA study does not definitively establish that service industries' increased consumption of telecommunications is responsible for the observed output growth for those industries. Indeed, for the retail trade and business services industries, the growth in output may largely be attributable to growth in employment.[87]

The second study, prepared by DRI and submitted to NTIA jointly by several telephone companies, employs an interindustry, input/output model to estimate the efficiency, or productivity, gains[88] that the U.S. economy realized in 1982 as a result of the increased consumption of telecommunications by various industry sectors and the more efficient production of telecommunications services between 1963 and 1982. Based on this analysis, DRI concludes that telecommunications enabled the U.S. economy to "save" $81.3 billion in labor and capital resources in 1982, $34.8 billion of which is due to increased consumption of telecommunications between 1963 and 1982, and $46.5 billion of which is attributable to improvements in the production of telecommunications over that same period.[89]

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[83] *See id.* at 15 and Apps. B-D.

[84] The industries are Finance, Business Services, Wholesale Trade, Retail Trade, and Insurance.

[85] Employment growth for the five service-related industries averaged 3.5 percent over that eight year period. Employment in manufacturing, mining, and agriculture declined some 1.4 percent over that same period. These latter industries, on average, spent less than .5 percent of their total output on telecommunications. The figure for the five service-related industries was 2.5 percent.

[86] Dick Conway and Assoc., *Rural Office Development in Washington State: Its Feasibility and the Role of Telecommunications* 6-7 (Jan. 1988) (submitted as App. 6 to Comments of Washington UTC).

[87] *See NERA Study, supra* note 29, at App. B.

[88] *See supra* note 28. Although DRI's analysis speaks in terms of efficiency gains, the study makes clear that (continued...)

DRI's methodology was criticized by the International Communications Association (ICA) and its consultants, Economics and Technology, Inc., on a number of grounds.[90] An NTIA staff review of DRI's analysis concludes that, although DRI's work is a constructive effort to address very complicated issues, it is nevertheless flawed in several respects, including its attempted quantification of the resource savings associated with improved production and increased consumption of telecommunications services.[91] On the other hand, as ICA notes, DRI's analysis does support the "general proposition that telecommunications growth has engendered positive benefits for the US economy."[92] There is no debate in the record, whether from marketplace participants or policy analysts, about the qualitative importance of telecommunications to the performance and productivity of the U.S. economy.

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[88] (...continued from preceeding page)
those gains, in effect, allowed the U.S. economy to produce the same level of output with fewer resources, *see, e.g., DRI Study, supra* note 28, at ii-iv, the hallmark of an increase in productivity. *See also* Supplemental Comments of ICA at 4 ("efficiency" gains cited in DRI Study are compared to direct total factor productivity studies; values are thus true productivity measures).

However, DRI's measures of efficiency, or productivity, are based upon usage of resource inputs (labor and capital) by the telecommunications industry as a whole, rather than on prices. As a result, those figures are not directly comparable to productivity measures, such as those used in the FCC's price cap proceeding, that are based upon comparisons between the overall level of inflation and the rate of inflation of telecommunications service prices for individual providers. *See DRI Study, supra* note 28, at 15 n.*.

[89] DRI estimates that increased consumption of telecommunications actually generated resource savings of $52.0 billion in 1982. *Id.* at vi, 28-36. These savings, however, were offset in part by a $17.2 billion increase in resources consumed by telecommunications firms to accommodate that expanded demand. *Id.* at vi, 36. The result is a net savings of about $34.8 billion.

[90] *See, e.g.*, Roddy, *A Review of the Points Raised in the Bell Companies' January 11, 1991 Letter to NTIA* (attached to Letter from Brian R. Moir, Fisher, Wayland, Cooper and Leader, to William F. Maher, Jr., NTIA (Feb. 6, 1991)); Roddy, *Analysis of DRI/McGraw Hill Telecommunications Infrastructure Report: "The Contribution of Telecommunications Infrastructure to Aggregate and Sectoral Economic Efficiency"* (submitted as Attach. B to Supplemental Comments of ICA).

[91] *See* Bykowsky, Maher, and Sloan, *DRI Study: A Review* (Oct. 1991) (attached hereto as Appendix C).

[92] Supplemental Comments of ICA at 3.

C. CONCLUSIONS

The foregoing discussion demonstrates that American businesses of all sizes and types are now using telecommunications extensively to reduce costs, increase productivity, and improve service to their customers. Just as Sherlock Holmes once solved a mystery by noting the absence of a dog's bark, however, it is equally important for us to note the ways in which American companies are not using telecommunications. Many of the most sophisticated applications cited above involve private networks used for internal communications within large companies, or between large companies and a more or less permanent base of suppliers and distributors. The public switched network provides fewer alternatives for residential consumers and for independent small businesses.

Thus, Boeing uses video conferencing to link engineers in the Puget Sound area. But Boeing does not report having the ability to dial up engineers in other parts of the country and bring them into videoconferences on an *ad hoc* basis, nor does it report having affordable dial-up access to broadband channels for rapid transmission of the massive data files used in computer-aided design and computer-aided manufacturing. An independent engineering firm in Pennsylvania with specialized expertise might not be able to establish effective communications with Boeing on short notice, and Boeing might therefore be deprived of the potential gains in efficiency or quality that such a firm might otherwise have provided.

JC Penney reports using video conferencing to discuss new products with potential buyers, but it cannot discuss new products with consumers in their homes. L.L. Bean's customers often call from home, but can only inspect Bean's merchandise when it arrives in the mail. Similarly, Anichini Linea Casa uses traditional telephone service, telex, and facsimile to inform retail buyers about new offerings of fine Italian linens, and that method of operation has built its sales to $3 million per year. What would its sales be if it could transmit life-like images? Photo-quality views of products on a dial-up basis, if made available through an affordable public telecommunications system, could have a significant effect on that merchant's business, and might ultimately transform the distribution sector of the American economy.

Moreover, the benefits of telecommunications for the U.S. economy are clear enough and pervasive enough to demonstrate the importance of telecommunications issues for policymakers. They emphasize the need for government to ensure that a competitive environment exists in which U.S. firms can continue to develop the services and capabilities that will allow U.S. firms and consumers to reap the net benefits that usage of telecommunications promises.

III. TELECOMMUNICATIONS AND ECONOMIC DEVELOPMENT

Anyone attempting to examine the relationship between telecommunications and economic development is quickly confronted with a "chicken and egg" problem: because telecommunications and other infrastructure investments and economic development commonly occur together, it is difficult to determine which "comes first" in a causal sense. The economic literature on this subject reflects this fundamental uncertainty. Some economists believe that infrastructure investments can "cause" economic and social development by attracting businesses to an area and, in turn, generating increases in employment, income, and standards of living.[93] Others contend that infrastructure investments occur simply to relieve "tensions" caused by economic development within an area, as in the case where a city constructs mass transit facilities to alleviate traffic congestion.[94]

Most economists, however, occupy the middle ground, concluding that although cause and effect cannot be determined precisely, positive, reciprocal relationships do exist between infrastructure investments and economic development.[95] The record in this proceeding displays a general consensus around this middle ground.[96] It is not surprising, therefore, that public and private organizations alike are currently exploring the use of telecommunications as a tool to promote economic development.

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[93] *See, e.g.*, Hardy, *The Role of the Telephone in Economic Development*, 4 Telecommunications Pol. 278 (Dec. 1980); Marsh, *Telecommunications as a Factor in the Development of a Country*, 24 IEEE Transactions on Communications 716, 716-717 (1976).

[94] *See, e.g.*, Glover and Simon, *The Effect of Population Density on Infrastructure: The Case of Road Building*, 23 Econ. Devel. and Cultural Change 453 (1975).

[95] *See* Looney and Frederiksen, *The Regional Impact of Infrastructure Investment in Mexico*, 15 Regional Stud. 285, 286-87 (1981); Shapiro, *Telecommunications and Industrial Development*, 24 IEEE Transactions on Communications 305, 306 (1976).

[96] *See* Comments of GTE Service Corp., App. A at 2, 4; Comments of Pacific Telecom, Inc. at 7-8; Comments of UTC at 4; Comments of NGA, Attach. 3; Comments of Enertel at 3-4; Comments of Jere Covington, *et al.* at 1-2; Reply Comments of NRTA at 3.

Of the many submissions in this proceeding, only the *DRI Study* attempts a rigorous examination of the relationship between investment in telecommunications infrastructure and economic development. For an analysis of this study, see Appendix C.

A. EFFORTS BY STATE/LOCAL AND FEDERAL GOVERNMENTS TO FOSTER ECONOMIC DEVELOPMENT THROUGH USE OF TELECOMMUNICATIONS

This activity is increasingly evident within all levels of government. State, federal, and local authorities have begun to promote or encourage investment in infrastructure to fuel economic development, particularly in rural areas.[97]

1. Current State/Local Activities

At the state/local level, potential linkages between telecommunications and economic development are a focus of attention for two distinct groups of policymakers: executive branch agencies (*e.g.*, governors' offices, economic development or planning agencies, and local governments) and state public utility commissions (PUCs). In the past, commenters assert, state executive agencies tended not to promote telecommunications in their economic development efforts.[98] In many cases, availability of telecommunications has been overshadowed by emphasis on other locational factors important to businesses, such as cost and quality of labor, taxes, or real estate costs.[99] In other cases, the differentials in telecommunications costs or capabilities from one region to another have not been great enough to give areas with lower costs or greater capabilities a definitive advantage.[100]

However, this view is changing, as state agencies increasingly recognize that telecommunications can enhance the future competitive position of their states and regions.[101] This new attitude about telecommunications as an engine for economic development is exhibited in myriad ways. About 12 states have appointed telecommunications task forces with an eye towards stimulating economic development.[102] For example, North Carolina has assembled representatives from education, business, industry, and the governor's office to study how telecommunications services can attract new businesses and to increase productivity.[103] Tennessee has developed a variety of state-directed or state-funded studies, projects, and proposals designed to create a telecommunications infrastructure that will promote, among other things, economic development within the state.[104]

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[97] *See, e.g.*, Comments of the National Ass'n of Towns and Townships at 1; Comments of Iowa Small Business Development Centers at 1; Comments of LMDDC at 2-5. *See also* Comments of BellSouth Corp., App. A at 16-19; Comments of TDS at 24-25.

[98] *See, e.g.*, Comments of the State of Minnesota at 4; Comments of GTE Service Corp., App. A at 9; Comments of NYNEX Corp. at 16. This is due, in large part, to the perception that availability of telecommunications is not yet a major determining factor in a firm's decision to locate in an area. *See* Comments of the State of Minnesota at 4.

[99] *See* Comments of BellSouth Corp., App. A at 18.

[100] *See* Comments of the State of Minnesota at 4. *See also Deloitte and Touche Study, supra* note 27, Vol. II, at V-27 (survey of economic development professionals indicated that "telecommunications infrastructure had been adequate enough . . . that it had not been a major issue when businesses located in one place vs. another in that region of the country").

[101] *See* Comments of NYNEX Corp. at 17; Comments of GTE Service Corp., App. A at 9-10.

Indiana's "State Technology Strategy" assigns telecommunications a high priority for both short and long-term actions.[105] Similarly, strengthening the state's telecommunications capacity is an integral part of Washington State's long-range strategic economic development plan.[106] Kentucky has also established a special program to attract service firms (such as mail order houses, telemarketers, and information processing companies) by emphasizing the state's telecommunications capabilities.[107] In May 1990, the Michigan Governor's Telecommunications Task Force issued a report that stressed the importance to Michigan of becoming a high-tech state, as well as the use of telecommunications to promote economic development.[108] Among other things, the task force recommended that Michigan create economic incentives for private telecommunications firms to install state-of-the-art technologies in their networks.[109]

The Hawaii State Business and Development Agency has established Kaitec, a form of business "incubator" facility[110] intended to nurture communications and information businesses within the state.[111] The facility is located in the central office of a local telephone company in space made available by the replacement of the company's electromechanical switching equipment with a digital switch. The State Department of Budget and Finance has organized Hawaii, Inc., a quasi-governmental corporation designed to (1) encourage and develop the state's information industry, (2) market Hawaii's information industry to commercial users, (3) develop a base of private information service providers, and (4) manage access to private information providers.[112] The corporation is now constructing a private network to give Hawaiian firms access to business development information held by a wide range of state agencies.

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[102] *See* Comments of Opt In America at 13.

[103] *See* Comments of BellSouth Corp., App. A at 22.

[104] *See* Comments of the University of Tennessee at 1-4.

[105] *See* Comments of GTE Service Corp., App. A at 9.

[106] *See id.*, App. A at 10; Comments of Global Telematics at 3. *See generally* Washington UTC, *The Status of the Washington State Telecommunications Industry* at 11-12, 47-48 (Feb. 15, 1991).

[107] *See* Comments of BellSouth Corp., App. A at 21.

[108] *See* Governor's Telecommunications Task Force, *Connections: A Strategy for Michigan's Future Through Telecommunications* (May 1990).

[109] *See id.* at 15-16.

[110] "Business incubators" provide small and start-up business owners with office space and basic support services to help them survive the initial phases of their operations. There are now roughly 400 such incubators operating throughout the United States. *See* Comments of GTE Service Corp., App. A at 8.

[111] *See* Comments of the State of Hawaii, App. D at 1.

The Minnesota Telecommunications Council has inventoried and compared the telecommunications infrastructure in Minneapolis-St. Paul and in the non-metropolitan areas of the state.[113] The State Planning Agency is examining the feasibility of updating and expanding its data base of telecommunications facilities within the state.[114] Once collected, this information will be incorporated into an integrated computer mapping data base along with maps of the state's cities, counties, and highways, economic and demographic data, information about natural resources. This assembled data base will then be made available to public and private sector users for system planning and business location evaluation. The state plans to have portions of this data base on-line by late 1991.

As an example of activity at the local level, Bloomsburg, Pennsylvania, has adopted a Strategic Management Plan that relies heavily on telecommunications as a way to help the community to adjust to projected losses in manufacturing jobs. The focal point of this plan is a proposal to construct a high-capacity microwave link between Bloomsburg and the major IXCs' points of presence in Harrisburg.[115] The community anticipates that this electronic "highway" to the outside world will help it both to attract new information-intensive businesses and to improve the competitiveness of its existing industrial base.[116]

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[112] *See id.*

[113] *See* Comments of the State of Minnesota at 4-5. The Council was created in 1984 by the Minnesota legislature to "promote coordination and to establish leadership in the use of advanced telecommunications resources in the public and private sectors." *Id.* at 4.

[114] Data to be collected include public switched network trunks (transmission medium, capacity, nodes), switches (type, access lines served, features, services), LATA boundaries, telephone company service areas, CATV service areas, satellite uplink and downlink locations.

[115] *See* Comments of the Town of Bloomsburg, PA at 3-5.

[116] *See id.*

While these initiatives have been pursued by the executive branches of state and local governments, a number of PUCs have explored ways to employ economic regulation as a tool for promoting telecommunications network modernization and, in turn, economic development. In New Jersey, the Board of Public Utilities commissioned the business consulting firm of Deloitte & Touche to assess the importance of telecommunications to state economic development, as well as the implications of existing government and regulatory policies on telecommunications development. Completed in February 1991, that report concludes that accelerated deployment of a reasonably priced, advanced telecommunications network in New Jersey would advance a series of state objectives, including economic development.[117]

The Tennessee Public Service Commission (PSC) has elected to adapt conventional rate of return regulation to the task of promoting economic development within the state. Specifically, the Tennessee PSC will allow all regulated LECs within the state to earn more than their authorized rate of return, although the firms will have only limited authority to raise basic telephone rates.[118] In return, the two largest LECs in the state must commit their excess earnings for a three-year period to network modernization in accordance with a state-developed master plan intended to accelerate deployment of such technologies as Signalling System No. 7, ISDN, and fiber optic cable.[119]

More commonly, however, state PUCs have sought to pursue network modernization and economic development objectives through various forms of incentive regulation. Under these plans, regulated telephone companies agree both to upgrade their networks and to constrain rate increases to some level below inflation in return for being freed, in whole or in part, from the profit constraints associated with rate of return regulation. For example, in October 1989, the California PUC adopted a price cap/profit sharing proposal for Pacific Bell.[120] Under that plan, regulated rates would be adjusted annually to keep pace with inflation (minus a productivity offset). The firm would also be allowed to retain some of its earnings in excess of its authorized rate of return. At the same time,

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[117] *See Deloitte and Touche Study, supra* note 27, Vol. I, at I-3, I-14 to I-15.

[118] At designated levels, certain portions of those earnings must be refunded to ratepayers. *See* Bell Atlantic, *Regulatory Reform Update* (Oct. 9, 1990); Telecommunications Reports, Aug. 9, 1990, at 12-14.

[119] *See* Bell Atlantic, *Regulatory Reform Update* (Oct. 9, 1990); Telecommunications Reports, Aug. 9, 1990, at 12-13.

[120] *Alternative Regulatory Frameworks for Local Exchange Carriers*, 107 PUR4th 1 (Cal. Pub. Util. Comm'n 1989).

Pacific Bell would invest $404 million to upgrade its network so that all of its switches would be capable of providing equal access to interexchange carriers.[121]

In March 1990, the Michigan PSC approved a plan under which Michigan Bell would be allowed to earn more than its authorized rate of return on the condition that a portion of any excess earnings be invested in network modernization in designated areas of the state, including the rural Upper Peninsula.[122] In January 1990, the Kansas Corporation Commission froze Southwestern Bell's business and residential basic telephone rates for five years, during which time the Commission would not alter the firm's profits. In return, Southwestern Bell agreed to replace its remaining 131 electromechanical switching offices with digital switches within five years. The company also committed to upgrade all existing party line customers to single line service within that same period.[123] At least four other PUCs have adopted plans similar to those approved in California, Michigan, and Kansas.[124]

2. Federal Activities

Federal telecommunications policies have also promoted economic development, if only indirectly. One clear example is the Rural Electrification Administration's (REA) loan program,[125] the principal source of direct federal funding for telecommunications investment. Although creation of the REA loan program was not motivated primarily by economic development considerations,[126] some contend that the more than $9 billion dollars in rural telephone loans that the agency has made to date[127] have produced incidental, or "spillover," effects that have promoted development.[128] Others claim that REA funding has helped rural telephone companies acquire and deploy modern equipment and facilities that enhance the attractiveness of rural areas as places for business.[129]

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[121] *See id.* at 104.

[122] *Michigan Bell Tel. Co.*, 111 PUR4th 1, 18-19, 21-22 (Mich. Pub. Serv. Comm'n 1990). The companies can retain a certain portion of any excess earnings, with the balance being refunded to ratepayers.

[123] *See* Telecommunications Reports, Jan. 8, 1990, at 1; Comments of Southwestern Bell Corp. at 8-9.

[124] The states are Minnesota (*see* Telecommunications Reports, May 28, 1990, at 9), Iowa (*see id.*, June 4, 1990, at 14), Texas (*see id.*, Feb. 12, 1990, at 8; Comments of Southwestern Bell Corp. at 10-11), and Missouri (*see* Telecommunications Reports, Oct. 10, 1989, at 15-16; Comments of Southwestern Bell Corp. at 9).

[125] 47 U.S.C. §§ 901-950b (1988). The Rural Electrification Act was enacted in 1936 to extend electrical service to rural areas. Act of May 20, 1936, ch. 432, 49 Stat. 1363. The Act was amended in 1949 to authorize funding for telephone service. Act of Oct. 28, 1949, ch. 776, 63 Stat. 948.

[126] The program was conceived in 1936, and expanded in 1949, as an effort to improve the quality of life for rural residents (primarily farm families) by giving them access to the electric and telephone services commonly available in more populated areas. *See, e.g.*, S. Rep. No. 1071, 81st Cong., 1st Sess., *reprinted in* 1949 U.S. Code Cong. & Admin. News 2330; 95 Cong. Rec. 13,869 (1949) (statement of Sen. Hill); 80 Cong. Rec. 5286 (1936) (statement of Rep. Maverick); *id.* at 5284 (statement of Rep. Rayburn). (continued...)

Recently, REA has begun to make economic development objectives a significant part of its funding activities, although telecommunications has not figured in such activities to date. In 1987, it established the Rural Economic Development Loan and Grant Program, which provides zero interest loans to REA-qualified borrowers to underwrite rural development and job creation projects.[130] Loans are made to qualified borrowers, which then turn the funds over to the specific project or parties being funded. To date, REA has committed $885,000 to fund 12 different projects, none of which involves telecommunications.[131] The enactment of Title 23 of the Food, Agriculture, Conservation, and Trade Act of 1990 (Farm Act)[132] has effectively codified REA's increased commitment to economic development objectives because, among other things, it requires the agency to establish a series of funding and technical assistance programs designed to promote rural economic development.[133] These provisions of the Farm Act are very controversial, however. Even in signing the Farm Act into law, President Bush warned that the provisions regarding rural telephone loans represent unwarranted increases in federal subsidies and, in effect, turn control of the lending program over to the borrowers.[134]

FCC regulatory policies have also indirectly promoted rural economic development. For example, the FCC has for many years required geographic averaging of interstate long

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[126] (...continued from preceeding page)
Interestingly, one proffered rationale for institution of the REA program in 1936 was that the electrification of rural America was lagging behind nations such as France, Germany, and Japan. *See id.* at 5279-80 (statement of Rep. Winthrow).

[127] *See* Reply Comments of NRTA at 4.

[128] One study has estimated that REA loans contributed $283 million to U.S. Gross Domestic Product in 1980, as well as $196 million in new tax revenues from REA borrowers and subscribers whose income increased as a result of having telephone service. E. Parker, *The Economic and Social Benefits of the REA Telephone Loan Program* (1983).

[129] *See* Comments of REA at 2-3; Reply Comments of NRTA at 2-3.

[130] *See* Comments of REA at 3.

[131] *See id.* at 3-4.

[132] Pub. L. No. 101-624, 104 Stat. 3359, 3979-4058 (to be codified at 23 U.S.C. §§ 2302-2396).

[133] *See id.* §§ 2335(a), 2343, 2345, 2346, 104 Stat. at 4021, 4027-4028, 4029, 4034.

[134] *See* Presidential Statement on Signing the Food, Agriculture, Conservation, and Trade Act of 1990, 26 Weekly Comp. Pres. Doc. 1926, 1927-28 (Dec. 3, 1990).

distance rates, thus ensuring that the price of a call between a rural community and an urban area is the same as a call of the same distance between two cities.[135] Further, the FCC has implemented programs that provide subsidies to so-called "high cost" areas (frequently rural areas).[136] As a result of these policies, service rates in rural areas are lower than they otherwise would be. This, in turn, reduces the likelihood that telecommunications costs will dissuade businesses from locating in otherwise attractive rural areas. The benefits of these programs have been reinforced by FCC decisions permitting long distance competition and altering the way in which the costs of local exchange access are recovered, which have produced sharp reductions in the price of long distance service for rural and urban customers alike.[137]

B. INSTANCES IN WHICH TELECOMMUNICATIONS HAS FACILITATED ECONOMIC DEVELOPMENT.

Although, as we have noted, the effect of infrastructure investments on economic development may be unclear in theory,[138] the record in this proceeding reveals numerous instances in which the availability of adequate telecommunications facilities has contributed to firms' decision to locate in a particular community. This is particularly true in rural areas, where the arrival of service firms has mitigated job losses in agriculture, mining, and manufacturing.[139]

In North Dakota, for example, Rosenbluth Travel, a Philadelphia-based firm, has located a branch office in Linton, population 1,460.[140] The office now employs 82 people and pays $1 million annually in salaries, which helps support the town's economy. Rosenbluth also estimates that operating costs at the Linton office are 20 percent lower than its other offices nationwide. Indeed, the company has been so satisfied with its Linton office that it is currently building a $1 million corporate retreat and farm just west of the town.

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[135] *See* 2 A. Kahn, *The Economics of Regulation* 147 (1988 ed.) (*Kahn*).

[136] *See, e.g., Amendment of Part 67 of the Commission's Rules and Establishment of a Joint Board*, 96 FCC 2d 781, 791-802 (1984).

[137] Finally, the FCC's decision to adopt price cap regulation for AT&T and certain LECs may further assist rural economic development. To the extent that such regulation eliminates or reduces FCC oversight of carrier investment decisions, those firms may have greater incentives to deploy advanced technology in rural areas, *see infra* notes 899-901 and accompanying text, thus enhancing those areas' attractiveness to business.

[138] *See supra* notes 93-95 and accompanying text.

[139] *See, e.g.*, E. Parker, H. Hudson, D. Dillman, and A. Roscoe, *Rural America in the Information Age: Telecommunications Policy and Economic Development* 11-27 (1989); *Davidson, supra* note 56, at 4.1.

[140] *See* Worthington, *Telecommunications Companies Tune in on North Dakota*, Wash. Post, Jan. 13, 1991, at B2.

Rosenbluth's success in Linton has prompted other firms to consider locating some of their service activities in North Dakota. U.S. Health Care, another Philadelphia-based company, has moved its claims processing operations to Bismark, where it will employ as many as 200 people.[141] Choice Inns has located its reservations center in Minot, where it may eventually hire up to 300 employees. Impact, a subscriptions telemarketing firm, will employ 25 people in Grafton, and the state development commission is courting at least three other telecommunications-related firms.[142]

Service firms have found fertile ground in other Midwestern states. The Electronic Marketing Research Group (EMRG), a company that provides software, consulting, and data-processing services for college financial aid offices, is based in the small farm community of Kearney, Nebraska. EMRG now employs seven telemarketers in Kearney and controls about 40 percent of the national market for its services.[143] EMRG's success helped Kearney persuade WATS Marketing, an American Express-owned telemarketing firm, to relocate one of its branch offices from Omaha to Kearney.

Nebraska is also home to the Peru Center for Telecommunications Marketing, Inc., the first campus-based telemarketing operation in the United States.[144] The center was founded in 1986 as a joint venture between Peru State University, a small teaching college in Peru, a town of 1,000 people, and Telecommunications Marketing, Inc. (TMI), a Texas-based telemarketing firm. To lure TMI to the town, the university persuaded Lincoln Telephone and Telegraph, the LEC serving Peru, to install new switching equipment and 20 miles of fiber optic cable, at a cost of $103,000. In its first year of operations, the center sold over $3 million worth of goods and services via telecommunications. It now employs over 100 people (mostly university students) and injects more than $1 million annually in salaries into the town's economy.

Iowa has pursued telemarketing as a growth industry for rural areas since 1985. As a result, the state is now home to more than 60 telemarketing firms, which employ some

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[141] *See id.*

[142] *See id.*

[143] *See Davidson, supra* note 56, at 4.2.

[144] *See id.* at 5.3.2-5.3.4.

4,500 people in 29 communities.[145] One such operation is in Breda, a town of 500 inhabitants. Breda's telemarketing center currently has more than 40 employees, mostly farm wives seeking to supplement their family incomes. Breda became an attractive location for telemarketing firms, in part, after the serving LEC, Breda Telephone Corporation, installed 13.5 miles of fiber optic cable, at a cost of $90,000, to connect the town with an interexchange carrier network.[146]

The economic opportunities that telecommunications helps to create for rural areas are not limited to service industries, however. In 1988-89, a joint venture between TRW and a Japanese company located a steering systems manufacturing plant in Tellico Plains, a rural community in East Tennessee. The firm's decision hinged, in part, on the serving LEC's ability to install a new digital switch in the town, at a cost of $500,000.[147] The plant will eventually employ some 600 people, more than 10 percent of the LEC's entire subscriber base.[148]

Rural communities are not the only potential beneficiaries of the economic development opportunities that telecommunications can facilitate. Urban and metropolitan areas, both large and small, have also sought to use telecommunications as a tool for attracting new businesses or retaining existing ones. The Notice mentioned two of the most prominent examples of such initiatives: the New York Teleport project and Citicorp's relocation of its credit card processing and reporting operations to Sioux Falls, South Dakota.[149] The record in this proceeding provides others.

For example, telecommunications has helped make Omaha, Nebraska, the telemarketing capital of the United States. In 1988 alone, an estimated 100 million calls traversed the public networks to telemarketers in the Omaha area.[150] More than 300 telemarketing

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[145] *See id.* at 5.1.3.

[146] *See id.* at 5.1.5.

[147] *See id.* at 1.5.2; Comments of TDS at 31-32.

[148] *See* Comments of TDS at 32. Several other firms are constructing or are planning to locate manufacturing plants in the same area, although it is not clear to what extent their decisions were influenced by the ability of advanced telecommunications facilities and services in the area. *See id.* at 32 n.59.

[149] Notice, 55 Fed. Reg. at 803, para. 22. Although the Notice referred to Sioux Falls as a rural area, one commenter points out the community has a population approaching 100,000, an urban area by most measures. *See* Comments of Idaho PUC at 4. For a discussion of the genesis of the Teleport project and a status report, see Reply Comments of Teleport Communications Group at 9-15, 19-21, 26-32.

[150] *See NERA Study, supra* note 29, at 26.

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firms are located in and around the city, employing over 100,000 people.[151] The presence of these firms has helped to reduce Omaha's unemployment rate to below three percent.[152]

Pueblo, Colorado, a city of more than 100,000 inhabitants, successfully used telecommunications to persuade American Express to locate some of its WATS telemarketing operations in the city.[153] Although American Express was impressed by the quality and commitment of the city's labor force, it was concerned that Pueblo's telephone system would not be able to handle the high volume of traffic from and to American Express' telemarketing facility. The Pueblo Economic Development Corporation therefore persuaded local and long distance carriers to upgrade their network facilities in the city, including installation of a new interexchange point of presence. The American Express telemarketing center now has 900 employees and handles up to 600,000 calls daily.

C. CONCLUSIONS

While individual states quite properly view telecommunications as a potential source of advantage when competing against each other for jobs and investment, the Federal government must necessarily take a different perspective. All of the states are or should be equally favored in terms of national policies, and we therefore ask what benefits telecommunications brings to the entire country.

It is obvious that even the most advanced telecommunications system cannot alone guarantee the economic health and prosperity of the United States. Availability of telecommunications may only be one factor in attracting new businesses to a community. This argues for an integrated approach in carefully using telecommunications policymaking in combination with other tools in order to stimulate development.[154]

What telecommunications can do is help reduce unnecessary geographic barriers to competition. The examples cited above indicate that the cost, quality, educational attainment, and commitment of the available labor force were major factors in each firm's decision to locate in the targeted community.[155] The president of Rosenbluth Travel extolled his employees in Linton, North Dakota, because "there is virtually no absenteeism or turnover."[156] North Dakota and Iowa are both attractive to prospective employers because their residents are, relatively speaking, well-educated and highly literate.[157] American Express considered locating in Pueblo, Colorado, in part, because its large Hispanic population could accommodate the firm's need for Spanish-speaking telemarketers.[158]

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[151] *See id.*; *Davidson, supra* note 56, at 4.2.

[152] *See Davidson, supra* note 56, at 4.2.

[153] *See id.* at 5.2.1-5.2.2.

[154] *See* Looney and Frederiksen, *The Regional Impact of Infrastructure Investment in Mexico,* 15 Regional Stud. 285, 287 (1981) ("most economists agree that if infrastructure investments, labour market planning, and educational planning are unconnected they are likely to yield conflicting results, or, at any rate, outcomes that could eventually lead to undesirable situations").

State government policies, such as the regulatory or tax climate are also important factors in firms' location decisions.[159] As commenters note, Citicorp's decision to locate its credit card operations in South Dakota seems attributable largely to changes in the state's banking regulations and repeal of its usury laws (thus, giving Citicorp flexibility in the interest rates charged to its cardmembers).[160] Iowa is attractive to telemarketing firms because of its favorable corporate tax rates and because it offers grants and low-interest loans to telemarketing and telecommunications firms.[161] In their efforts to attract new telecommunications-based businesses to their communities, Peru, Nebraska, and Pueblo, Colorado, also provided office space at no or reduced cost.[162]

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[155] This is consistent with earlier studies, which found that labor costs have been the most important factor in firms' location decisions. *See, e.g.*, Kale and Lonsdale, *Factors Encouraging and Discouraging Plant Location in Non-Metropolitan Areas*, in *Non-Metropolitan Industrialization* 47, Lonsdale and Seyler, eds. (1979); Carlton, *Why Firms Locate Where They Do: An Econometric Model, Interregional Movements and Regional Growth* 13, W. Wheaton ed. (1979). *See also* Bergeron, *Corporate Executives Rate Site Selection Factors*, Area Devel., Dec. 1989, at 20 (cited in *Deloitte and Touche Study*, *supra* note 27, Vol. II, at V-7) (survey of business executives finds that 96.2 percent of those questioned stated that labor costs were "very important" or "important" to their firms' location decisions).

[156] Worthington, *Telecommunications Companies Tune in on North Dakota*, Wash. Post, Jan. 13, 1991, at B2.

[157] *See id.*; *Davidson*, *supra* note 56, at 5.1.3.

[158] *See Davidson*, *supra* note 56, at 5.2.2. Approximately 25 percent of all inbound calls to American Express' Pueblo facility are in Spanish.

[159] The MESA Report suggests that sweeping changes in Nebraska telecommunications regulatory policies contributed significantly to the growth of telemarketing businesses in Nebraska. *Id.* at 4.2. However, it appears that other factors provide a better explanation for the rise of Omaha and other Midwestern cities as telemarketing centers. Historically, AT&T's WATS rate structure was such that a firm could most cheaply acquire WATS service to all parts of the country by locating in the middle of the United States. *See* Feder, *Omaha: Talk, Talk, Talk of Telemarketing*, N.Y. Times, July 20, 1991, at 43 (*Feder*). Locating in the Midwest also enables telemarketing firms to operate as many as 16 hours per day. *See Davidson*, *supra* note 56, at 5.1.3. Moreover, Midwesterners have an accent-free speech, that is easily understood everywhere in the country. *See Feder* at 43. Although the regulatory climate may have reinforced these other advantages, it is noteworthy that Nebraska gained its reputation as the "800 [telemarketing] capital of America" several years before passage of the 1986 law that fundamentally changed telecommunications regulation in that state. *See, e.g.*, Dittrick, *800 phone number response centers grow in Nebraska despite recession*, UPI Newswire, Apr. 27, 1982. Moreover, Nebraska's favorable regulatory environment has not saved Omaha from losing telemarketing firms to other Midwestern communities. *See Feder* at 43.

[160] *See* Reply Comments of Heather Hudson at 2; *Davidson*, *supra* note 56, at 7.2.2.

Thus, telecommunications does not obviate the importance of a well-educated, hard-working labor force, reasonable tax rates, affordable real estate, and other factors of production. In the past, business enterprises looked for the most productive workers close at hand. Today and, to an increasing extent in the years ahead, firms may seek maximum productivity wherever they can find it, whether nearby or far away, because telecommunications will make it accessible. For many kinds of tasks, an advanced, affordable telecommunications infrastructure will make available to companies the best workers and the best suppliers anywhere in the nation. Competition will require that companies avail themselves of those opportunities. Increased rivalry among domestic firms, aided by improved telecommunications, will strengthen America's ability to compete in the global economy[163] and, in time, will bring a higher standard of living to all of us.

IV. TELECOMMUNICATIONS AND DELIVERY OF CRITICAL SERVICES

The benefits that telecommunications can produce extend beyond the realm of economic development. Indeed, the Notice and the record in this proceeding have identified a variety of ways in which telecommunications can enhance the nation's social welfare by improving delivery of critical services, such as education, health care, security and public safety services.[164] Telecommunications also plays a crucial role both in protecting our national security and in helping the nation respond effectively to emergency situations and natural disasters. Government agencies work continuously to ensure that the U.S. telecommunications infrastructure is sufficient to meet such national security/emergency preparedness (NSEP) needs. Telecommunications policymakers must be sensitive to those activities and ensure that regulatory policies and decisions are compatible with NSEP objectives.

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[161] *See Davidson, supra* note 56, at 5.1.3.

[162] *See id.* at 5.2.2, 5.3.4.

[163] M. Porter, *The Competitive Advantage of Nations* 143-144, 216, 224, 560-562, 597-598 (1990).

[164] *See, e.g.*, Notice, 55 Fed. Reg. at 805-807, paras. 38-54; Comments of LMDDC at 6-10; Comments of the State of Hawaii at 6; Comments of NYNEX Corp. at 26-70.

To provide a sense of the ways in which telecommunications can be used in the delivery of critical services, the following discussion focuses on two categories of such services—education and health care.[165] Specifically, we will examine available evidence concerning use of telecommunications to provide those services and consider what implications that may have for telecommunications policymaking.

A. EDUCATION

Communications technologies are used to promote educational objectives in a number of different ways. One such example is the "Internet," which facilitates interaction between and among researchers in institutions of higher education. The Internet is not a single network, but a collection of networks, each serving the individual needs of government agencies, university researchers, and industry laboratories. Formed in the late 1980s through the gradual interconnection of existing scientific and academic networks, the Internet provides users great potential for computing, communicating, and information retrieval.

The genesis of the Internet was in the ARPANET, the first academic research network, developed in 1969 by the Advanced Research Projects Agency (ARPA, now the Defense Advanced Research Projects Agency, or DARPA).[166] In the two decades since the ARPANET was built,[167] a number of organizations and government agencies have developed specialized networks, including MERIT, a state wide higher education network in Michigan, founded in 1972; CSNET, developed for computer sciences research and engineering and funded by the National Science Foundation (NSF); and BITNET, formed in 1981 to provide low-cost network access to scholars. In 1986, NSF entered an agreement with MERIT—in partnership with IBM and MCI—to build a supercomputer network, NSFNET, to facilitate access to the national supercomputing centers. The NSFNET acts as the backbone of the Internet, supporting several mid-level or regional networks and hundreds of campus networks. NSFNET, which began using data rates of 56 kilobits per second, but quickly became saturated, upgraded its lines to T1 rates (1.5 megabits per second) and by the end of 1991 will upgrade to T3 rates (45 megabits per second).

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[165] Although the Notice mentions public safety services, *see* Notice, 55 Fed. Reg. at 806, paras. 44-46, we will not discuss them separately in this subsection. Other parts of this report discuss public safety services when appropriate. In Chapter 7, for example, we consider whether certain such services (*e.g.*, 911) should be included as part of universal service.

[166] ARPANET pioneered the data transmission technique known as packet switching, in which data are not sent in a continuous stream from one computer to another, but rather are divided into a series of data packets that can take separate routes through the network. *See infra* notes 405-410 and accompanying text for additional information on packet switching. Packet switching techniques were later successfully implemented in several VANs.

[167] ARPANET ceased operation in Spring 1990.

Federal funding of the Internet primarily supports the NSFNET, with diminishing funding to the regional or "mid-level" networks. There is also implicit federal funding of the network through NSF and other agency research grants to universities. State, local, and private concerns fund the remainder.[168] In funding the network, NSF's objective is to support scientific research, while other federal agencies' funding is to support their individual missions. However, the motivations for funding at the lower levels of the Internet hierarchy are more diffuse, for example, using connection to the network as a vehicle for economic development or encouraging communication between academia and industry.[169]

While the T3 data rates planned for the Internet are significantly higher than those previously available, the scientific and educational communities are seeking to communicate at much higher rates (*i.e.*, at gigabit rates). Earlier this year, as a supplement to the President's fiscal year 1992 budget, the Office of Science and Technology Policy submitted to Congress the Federal High Performance Computing and Communications (HPCC) Program.[170] In addition to funding for other components, the Program proposes a total investment of $91.9 million in a new National Research and Education Network (NREN), representing approximately a 30 percent increase over the fiscal year 1991 enacted levels. The program will provide support for "Interim NREN" activities that are designed to upgrade the NSFNET, assist in the upgrade of regional networks, and interconnect other agencies' backbone networks. Moreover, DARPA will continue to coordinate research and development on very high speed switches, protocols, and computer interfaces.[171] Congress is also considering three bills that would establish an NREN.[172]

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[168] For example, over the last 5 years, IBM and MCI have invested more than 3 times the $28 million contributed by NSF to operate NSFNET. *See* Communications Daily, June 5, 1991, at 4.

[169] *See* Kahin, *The Quasi-Public Network: Issues of Pricing and Access*, presented at the 17th Annual Telecommunications Policy Research Conference, at 2 (Oct. 3, 1989).

[170] *See* Federal Coordinating Council on Science, Engineering, and Technology (FCCSET), *Grand Challenges — High Performance Computing and Communications: A Report by the Committee on Physical, Mathematical, and Engineering Sciences to Supplement the President's Fiscal Year 1992 Budget* (1991). The HPCC Program's goal is to "accelerate significantly the commercial availability and utilization of the next generation of high performance computers and networks." The Program reflects the cooperative efforts of the several agencies, including DARPA, NSF, NASA, and DOE, that, for years, have been involved in scientific computing and networking. The HPCC Program follows a previous FCCSET report, *A Research and Development Strategy for High Performance Computing* (submitted to Congress in 1987), and the initial plan for *The Federal High Performance Computing Program* (submitted to Congress in 1989).

Very commonly, communications facilities and services are used to extend educational instruction beyond the boundaries of the traditional classroom. Such a use is, of course, not a new concept.[173] Many people doubtless recall "Sunrise Semester" and the other instructional programming that appeared on broadcast television stations in the 1950s and 60s. "Broadcast" technologies like radio, television, and cable television continue to play a major role in providing so-called "distance learning."[174] More than 80 percent of all public television broadcast stations provide instructional programs and services for use by elementary and secondary schools, or institutions of higher learning.[175] The Public Broadcasting Service, in conjunction with over 300 public television stations, offers college level courses to more than one million people nationwide.[176]

Educational services are also being provided via cable television systems. Two major cable programming channels, Cable News Network and the Discovery Channel, are now producing commercial-free news and current affairs programming for transmission to the classroom.[177] Another cable network, Mind Extension University, has been offering high school and college courses to cable subscribers since 1987.[178] The network, in conjunction with nine universities, plans to offer the nation's first complete bachelor's degree program by distance learning starting in late 1991.[179]

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[171] *See* FCCSET, *Grand Challenges—High Performance Computing and Communications: A Report by the Committee on Physical, Mathematical, and Engineering Sciences to Supplement the President's Fiscal Year 1992 Budget* 19 (1991).

[172] *See* S. 343, 102d Cong., 1st Sess. (1991); S. 272, 102d Cong., 1st Sess. (1991); H.R. 656, 102d Cong., 1st Sess. (1991).

[173] Indeed, many of the technologies now being used to extend instruction beyond the classroom (*e.g.*, broadcast television, instructional fixed television, microwave radio) predate World War II. *See* Comments of Kirkwood Community College at 2.

[174] The term "distance learning" has been broadly defined as "the transmission of educational or instructional programming to geographically dispersed individuals and groups." Office of Technology Assessment, U.S. Congress, *Linking for Learning: A New Course for Education*, OTA-SET-430, at 25 (Nov. 1989) (*OTA Report*). Distance learning is as old as the correspondence courses first offered in the early 1800s. *See* McLarin, *Learning From Afar: Connecting Teachers and Students Via High Technology,* Wash. Post, Feb. 22, 1990, at B5. In this report, however, we will use the term to refer only to instances in which educational services are provided to geographically dispersed locations via "telecommunications," as we have defined that term. *See supra* note 6 and accompanying text.

[175] *See* Comments of CPB at 33. All levels of government should ensure that their telecommunications regulatory policies do not hamper public broadcasters' ability to continue providing these important educational services in the future. *See* America's Public Television Stations, *Public Television Supports the Preservation and Enhancement of Public Telecommunications in Broadband Initiatives and Emerging Telecommunications Infrastructures* (1991).

[176] *See* Comments of NAPTS/PBS at 25-26. For a further description of the educational services provided by America's television broadcast stations, see Comments of NAB at 9-11; Comments of INTV at 14-15.

At the same time that new and innovative ways are being developed to use these broadcast-type technologies as vehicles for providing educational programming at a distance, distance learning applications employing telecommunications facilities are also expanding rapidly. According to the Office of Technology Assessment (OTA), as recently as 1987, fewer than 10 states were investing in distance learning.[180] By the end of 1989, virtually all states were involved to some degree in distance learning projects.[181] In 1990, roughly one-third of all school districts in the United States were using distance learning.[182]

Several major developments have fueled this dramatic growth. First, as noted in the President's AMERICA 2000 Education Strategy, some have observed that "schools are one of the few institutions in society largely untouched even by the Industrial Revolution, much less by the Information Age."[183] Accordingly, there is heightened interest in exploring whether and how telecommunications and other Information Age technologies can be used to improve the quality of education in the United States.

Second, recognizing our nation's need for a skilled, well-trained work force,[184] states have been stiffening requirements for curriculum and graduation. Increasingly, however, elementary and secondary schools in rural areas lack the resources needed to provide the required courses.[185] Rather than close or consolidate (which for many rural communities would be very disruptive for students, teachers, and community alike), rural schools have turned to distance learning as a tool for helping them satisfy their expanded educational mandate. At the same time, large urban school districts are also finding that distance learning may help them overcome current shortages in qualified teachers in subjects like mathematics, advanced sciences, and languages.[186]

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[177] *See* Piccininni, *Commercial-Free TV Now in Some Schools: Rival Tries to One-Up Channel One,* Chicago Trib., May 28, 1990, at 9.

[178] *See* Communications Daily, Feb. 22, 1991, at 4.

[179] *See id.* at 3-4.

[180] *See OTA Report, supra* note 174, at 27.

[181] Appendix A of the *OTA Report* provides a thorough inventory of these state efforts.

[182] *See OTA Report, supra* note 174, at 27.

[183] U.S. Dep't of Education, *AMERICA 2000: An Education Strategy* 30 (Apr. 1991) (*AMERICA 2000*).

[184] Many observers believe that the productivity and competitiveness of the U.S. economy rests on the quality our labor force. *See, e.g., CEA Report, supra* note 3, at 121; National Telecommunications and Information Administration and International Trade Administration, U.S. Dep't of Commerce, *U.S. Telecommunications in a Global Economy: Competitiveness at a Crossroads* 208 (Aug. 1990) (*Competitiveness Report*); *Crisis in the Workplace: The Mismatch of Jobs and Skills: Hearing Before the Joint Economic Committee,* 100th Cong., 1st Sess. 3 (1989) (statement of Roberts T. Jones, Assistant Secretary of Labor for Employment and Training).

Finally, declining enrollments have motivated colleges and universities to seek out and serve student populations beyond the traditional campus environment.[187] Rapid and continual changes in the skills required of workers in a modern economy,[188] which require employees to engage in continuous, or "lifetime," learning, have reinforced this trend. Distance learning can help postsecondary education institutions reach and serve the non-traditional students that are increasingly important to some institutions' financial viability. It also gives employees an opportunity to hone or enhance their job skills without having to return to the campus.

1. Federal Government Involvement in Distance Education

Although most distance learning projects occur at the state or local level, the federal government is also active in this area. Although the President's Education Strategy emphasizes that the "secret ingredient [to great schools] is human, not electronic,"[189] it recognizes, nonetheless, that some schools can and will make effective use of distance learning and other modern tools in fulfilling their educational mandates.[190] Further, the President has charged the Secretary of Education to convene a group of experts to help determine how one or more electronic networks might be designed to provide schools with ready access to the best of information, research, instructional materials, and educational expertise.[191] These networks "may eventually serve all American schools as well as homes, libraries, colleges and other sites where learning occurs."[192]

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[185] *See OTA Report, supra* note 174, at 27-28.

[186] *See id.* at 28. A 1987 survey by the National Science Foundation found that 63 percent of high school principals had difficulty hiring qualified chemistry teachers. Comparable figures for computer science and mathematics were 62 percent and 57 percent, respectively. *See* Comments of Northern Telecom at 28.

[187] *See* Comments of Kirkwood Community College at 4; Comments of West Chester University at 2.

[188] A 1986 study by the National Research Council estimated that the time it takes for one-half of a worker's skills to become obsolete has declined from 7-14 years to 3-5 years. *See Crisis in the Workplace: The Mismatch of Jobs and Skills: Hearing Before the Joint Economic Committee*, 100th Cong., 1st Sess. 8 (1989) (statement of Roberts T. Jones, Assistant Secretary of Labor for Employment and Training).

[189] *See AMERICA 2000, supra* note 183, at 30.

[190] *See id.* at 16.

The primary federal role in support of educational telecommunications prior to the Education Strategy has been to provide funding for distance learning projects. The vehicles for providing such funding include the Star Schools program, instituted by Congress in 1988,[193] and NTIA's Public Telecommunications Facilities Program (PTFP), established by Congress in 1978.[194] Under Star Schools, the Secretary of Education awards grants to statewide or multistate "telecommunications partnerships" for the development and delivery of instructional course work in subjects such as mathematics, economics, geography, science, foreign languages, literacy skills, and vocational education.[195] At least 50 percent of Star Schools grant monies are reserved for educational organizations serving a significant number of poor students.[196]

In 1988, Congress authorized $100 million for the Star Schools program for a five-year period ending in September 1992.[197] In the first round of grants, the Secretary of Education awarded $33.5 million in grants to four partnerships.[198] Those organizations currently provide courses to over 15,000 students in some 1,500 schools in more than

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[191] President Bush also recently announced formation of the New American Schools Development Corporation, a nonprofit organization that will fund the design of new educational systems. This work could include greater use of telecommunications in education. *See* Presidential Remarks Announcing the New American Schools Development Corporation Board, 27 Weekly Comp. Pres. Doc. 897 (July 12, 1991).

[192] *AMERICA 2000, supra* note 183, at 18.

[193] *See* 20 U.S.C. §§ 4081-4086 (1988), as added by the Augustus F. Hawkins-Robert J. Stafford Elementary and Secondary School Improvement Amendments of 1988, Pub. L. No. 100-297, § 2032, 102 Stat. 130. These provisions were recently amended by the School Dropout Demonstration Assistance Act of 1991, Pub. L. No. 102-103, §§ 301-305, 105 Stat. 497.

[194] *See* 47 U.S.C. §§ 390-393, 397 (1988).

[195] *See* 20 U.S.C. §§ 4081, 4083 (1988). *See also OTA Report, supra* note 174, at 136.

[196] *See* 20 U.S.C. § 4082(c)(3) (1988); *OTA Report, supra* note 174, at 136. At least 25 percent of the total costs of any funded project must be covered by non-federal monies. *See* 20 U.S.C. § 4082(d)(1) (1988). *But see id.* § 4082(d)(2).

[197] *See* 20 U.S.C. § 4082(b)(1) (1988). In July 1991, Congress amended its funding of the program to authorize $50 million for fiscal year 1992 and "such sums as may be necessary in fiscal year 1993." *See* School Dropout Demonstration Assistance Act of 1991, Pub. L. No. 102-103, §§ 302(2)(A), 105 Stat. 497.

[198] *See OTA Report, supra* note 174, at 136-138. The grantees are the Satellite Educational Resources Consortium, TI-IN United Star Network, The Midlands Consortium, and Technical Education Research Centers. These four partnerships were selected from more than 70 applicants. *See id.*

40 states.[199] The courses range from Basic English through Russian, Spanish, and German to Advanced Placement physics, genetics, and applied economics.[200]

In October 1990, the Secretary of Education awarded $14.8 million in grants to four new partnerships.[201] These projects focus primarily on providing math, science, foreign language, and bilingual instruction to "at-risk" students in economically disadvantaged areas and urban school districts. They will eventually serve students in more than 100 schools in more than 12 states.

Under PTFP, NTIA has provided funding for several distance learning applications, including satellite uplinks, instructional fixed television systems (ITFS), and microwave facilities.[202] Also, the Department of Education has a variety of funding programs that can be used to support distance learning projects.[203] Although few of these programs have been tapped for distance learning, the University of Maine has received a 5-year $4.4 million grant under Title III of the Higher Education Act of 1965, as amended, to fund its statewide Community College of Maine/Telecommunications System.[204]

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[199] *See id.* at 138; Comments of Midlands Consortium at 4; Reply Comments of Opt in America at 2.

[200] *See* Comments of Midlands Consortium at 4.

[201] *See Deloitte and Touche Study, supra* note 27, Vol. II, at VI-24 to V-25. The grantees are the Educational School District in Spokane, Washington, the Massachusetts Corporation for Educational Telecommunications, the Los Angeles County Office of Education, and the Black College Satellite Network.

[202] For example, in fiscal year 1991, NTIA awarded some $118,000 in PTFP grants to fund ITFS systems in Tennessee and Kansas. We also awarded $500,000 to the Agricultural Satellite Corporation to fund expansion of its AG*SAT network, which provides educational programming and teleconferencing on agricultural issues to universities, extension programs, and agribusinesses nationwide. Finally, NTIA granted $392,000 to the Massachusetts Corporation for Educational Telecommunications to fund the acquisition of a mobile/production/uplink vehicle that will be used to provide instructional services to institutions within Massachusetts and throughout New England. *See* National Telecommunications and Information Administration, U.S. Dep't of Commerce, *1991 PTFP Grant Awards Summary*.

In fiscal year 1990, NTIA awarded some $350,000 in PTFP grants to fund ITFS systems in Michigan and New Mexico. We also awarded $735,000 to commence construction of the AG*SAT network. *See* National Telecommunicationsand Information Administration, U.S. Dep't of Commerce, *Public Telecommunications Facilities Program Grant Awards for Fiscal Year 1990.*

However, the bulk of PTFP's available funds are generally awarded to priority projects under its mandate, such as equipping new public broadcast stations and extending public radio and television service to unserved areas. Thus, in 1991, about 92 percent of PTFP's total grant funds of $19.7 million were awarded to these priority projects. In 1990, about 90 percent of some $20.7 million in funds were allotted to such projects. *See* National Telecommunications and Information Administration, U.S. Dep't of Commerce, *PTFP Awards for Fiscal Year 1991*; National Telecommunications and Information Administration, U.S. Dep't of Commerce, *Trends in PTFP Awards, 1982-1990.*

[203] *See OTA Report, supra* note 174, at 142-43.

[204] *See id.* at 143.

The federal government's role in distance learning is not limited to funding non-federal projects. For example, the Department of Defense Dependent School (DoDDS) system provides elementary and secondary education to 155,000 children of armed services personnel in 32 countries.[205] Students at DoDDS schools in Germany, Okinawa, Korea, and Italy are currently learning the Pascal computer language via telecommunications links from the University of Michigan.[206] Video-based instructional programming may be offered once DoDDS completes installation of its fiber optic management information system in DoDDS schools and administrative offices around the world.

The Department of the Interior's Bureau of Indian Affairs (BIA) operates 111 schools in 27 states,[207] all of which make some use of distance learning in fulfilling their instructional mandate. Nineteen BIA schools receive programming from the TI-IN United Star Network, one of the four original Star Schools grantees.[208] Additionally, all BIA schools are now connected to the Eastern Navajo Agency Network, a computer network that permits students to communicate with "pen pals" from other schools. More importantly, perhaps, the network enables teachers at BIA schools to discuss teaching strategy amongst themselves and with professors at the Universities of Kansas and New Mexico. In this way, the network helps enhance the quality of instruction (and, thus, the quality of education) at BIA schools.

2. Examples of Distance Learning Projects

Although the federal government plays a significant role in distance learning, the bulk of the activity occurs at the state and local level. The nature and scope of these activities vary widely, however, as the following examples make clear. While the subsequent discussion does not provide an exhaustive list of the many distance learning projects ongoing in the United States, we think it does offer a representative description of the ways in which telecommunications can be used to provide educational programming, as well as the technologies that are being employed to that end.[209]

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[205] This student population makes the DoDDS system the ninth largest school district in the United States.

[206] All told, about 90 of the 270 DoDDS schools have begun to use telecommunications for educational instruction.

[207] Another 71 schools are operated by Native American tribes and tribal organizations under contract from the BIA. *See OTA Report, supra* note 174, at 145-146.

[208] BIA purchases satellite receive equipment for the schools, and pays TI-IN $240 per student for each course received.

Texas is examining distance learning as a part of "Project Bluebonnet," a nonprofit research and public education corporation formed to enhance the economic competitiveness of the state.[210] The state has now initiated preliminary work to develop an experimental interactive network that can provide audio and two-way full motion video among geographically dispersed classrooms. Its objective is to study whether distance learning can be used to address problems, such as educational equity, lack of resources and qualified teachers, and adult literacy.

In upstate New York, the Delaware-Chenango Board of Cooperative Educational Services (BOCES) has operated an "audiographics"-based[211] distance learning network since 1985.[212] Eighteen school districts in four predominantly rural counties are interconnected by voice-grade telephone lines. Each location occupied by instructor and students is a classroom equipped with microphones, a computer keyboard, a video monitor, and a graphics tablet.[213] Thus, although teacher and students cannot see each other, students can readily communicate with the instructor and among themselves by voice, script, or pictures. Through this network, BOCES has been able to offer courses in college level English and mathematics, advanced foreign languages, and science to a total of some 40 students in a dozen schools.[214] The network costs (excluding telephone charges) are between $5,000 and $10,000 per location.[215]

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[209] For more comprehensive picture information on the ways in which telecommunications is now being used to provide distance learning, see *OTA Report, supra* note 174, *passim* and *Deloitte and Touche Study, supra* note 27, Vol. II, at Chapter VI.

[210] *See* Telecommunications Reports, Mar. 11, 1991, at 1-2.

[211] As the term implies, an "audiographics" system involves the two-way transmission of voice and graphic images.

[212] *See OTA Report, supra* note 174, at 8; Gilcher and Johnstone, *A Critical Review of the Use of Audiographic Conference Systems by Selected Educational Institutions* at 20-21 (Nov. 1988) (*Gilcher and Johnstone*).

[213] *See Gilcher and Johnstone, supra* note 212, at 2-4 and Figures 1 and 2. There may or may not be students in the classroom from which the teacher instructs.

[214] *See id.*; *OTA Report, supra* note 174, at 8. In at least one instance, the BOCES network provided at-home instruction to a student recovering from back surgery.

[215] *Gilcher and Johnstone, supra* note 212, at 2 n.1, 116-17. By way of comparison, a two-way video delivery system would cost about three times as much. *See id.* at 117. Participants in several ongoing audiographics-based distance learning projects generally agree that there should be no more that 10 classrooms and 35 to 40 students involved in any one project. *See id.* at 61. Given this average class size of 3.5 or 4 students, the costs per site of an audiographics network would be $1,250-$2,860 per student.

A number of other distance learning projects are also using audiographics technology. For example, the Division of Continuing Education at Louisiana State University uses audiographics technology to provide college-level instruction for students who are not able to attend regular courses at the university's Baton Rouge campus.[216] LSU now offers as many as eight courses per term to students in one to five different locations. Mansfield University in Pennsylvania uses audiographics to provide some 19 different courses to college-bound high school students, elementary school pupils, and educable mentally retarded high school students.[217]

At the same time, others are exploring the suitability of the copper-based public switched network for delivery of video in distance learning applications. Thus, Appalachian State University, AT&T Network Systems, and Southern Bell Telephone have announced plans to provide interactive voice, data, and video to three North Carolina schools as part of a distance learning project.[218] Using Southern Bell's ISDN service, the project will be "one of the first in the nation to deliver interactive video instruction through existing copper telephone lines."[219] The 10-year project eventually will be implemented in public schools in six North Carolina counties.

Maine is currently deploying its Community College of Maine/Telecommunications System, an ambitious plan to employ telecommunications to expand educational opportunities for students in rural schools, as well as for the two-thirds of the population that is not within reasonable commuting distance of the state's seven college campuses and six postsecondary vocational-technical institutes.[220] Maine plans to connect the seven campuses of the state university system with a fiber optic backbone that will furnish three channels of two-way video, audio, and data.[221] ITFS facilities, with two channels capable of providing one-way video, audio, or data (with an audio return), will extend the fiber backbone to other locations. The university campus in Augusta will be the hub of a statewide satellite network reaching all high schools, government buildings, hospitals, and cable television systems within the state. The total cost of the system will be in excess of $6 million.[222]

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[216] Before installing its distance learning network, LSU professors involved in off-campus instruction generally had to drive to off-campus instructional centers.

[217] *See Gilcher and Johnstone, supra* note 212, at 12-13. Mansfield University has also created a "teleteaching" program that has provided instruction on distance teaching techniques to more than 400 teachers in 10 states. *See* Applications of General Applications Programming, Inc. for a Star Schools Grant at 10-11.

[218] *See* Telecommunications Reports, May 6, 1991, at 8.

[219] *See id.*

[220] *See OTA Report, supra* note 174, at 116.

[221] Each of the seven campus sites will originate and transmit programming for the network. *See id.*

Other entities are relying heavily on satellite technology to provide a variety of instructional programming over broad geographic areas. For example, since August 1985, the National Technological University (NTU), a consortium of 28 engineering universities, has been offering instructional programming to engineers, scientists, and technical managers in the laboratories and offices of 60 participating corporations and government agencies.[223] Programming is transmitted from the universities to the remote "classrooms" via satellite, with return communications being completed by standard telephone lines.[224] NTU now offers some 455 courses in curricula leading to Masters of Science degrees in computer engineering, computer science, materials science, and electrical engineering.[225]

In September 1986, Washington State Educational Service District 101 established the Satellite Telecommunications Education Programming (STEP) Network to deliver high school credit courses to 13 schools where the District could not provide qualified teaching personnel.[226] Today, the STEP network provides its programming to more than 100 high schools in 12 states.[227] Students receiving the courses via satellite are connected with a teacher by 800-service facilities. Schools can access the STEP network by paying an annual membership fee and between $5,000 and $6,000 for satellite receiver equipment.

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[222] The State of Iowa is also melding a similar variety of telecommunications technologies into a statewide network designed, in part, to expand educational opportunities in that predominantly rural state. *See id.* Likewise, Minnesota employs a wide range of technologies to provide instructional programming to state residents of all ages. *See* Comments of the State of Minnesota at 6-10.

[223] *See OTA Report, supra* note 174, at 105; Notice, 55 Fed. Reg. at 805, para. 40. NTIA's PTFP program has awarded NTU four separate grants to institute and extend its network.

[224] *See OTA Report, supra* note 174, at 105. Classroom instruction is supplemented by electronic mail, computer teleconferencing, and telephone office hours.

[225] *See id.*

[226] *See id.* at 6-7.

[227] Courses include Japanese, Spanish, Calculus, and Advanced Senior English.

The Midlands Consortium, one of the four original Star Schools grantees,[228] currently transmits 13 different courses[229] to more than 5,000 students in some 28 states.[230] The Consortium's programming is transmitted by satellite to students in distant locations who respond via telephone.[231] Schools pay Midlands $300 per course per student and typically expend some $3,000 for the satellite dish and associated equipment needed to receive the Consortium's programming.[232]

Satellite technology is also at the heart of the Jason Project, which was conceived by a scientist at the Woods Hole Oceanographic Institute in Massachusetts as a way to expose students to the process of scientific discovery and, perhaps, to spark their interest in science as a career.[233] Jason is a remotely operated robot vehicle that travels along the ocean floor sending pictures and data via fiber optic cable to scientists on the "mother" ship on the surface. Those pictures are then sent via satellite, along with the scientists' observations and interpretations, to students in 12 museum sites in the United States and Canada. Each "class" lasts one hour, including a question and answer session between the students and the scientists. In preparation for this unconventional "field trip," the students study a specially developed curriculum in science, social science, and history.[234]

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[228] The members of the consortium are the University of Alabama at Birmingham, the University of Kansas, Kansas State University, the University of Mississippi, Oklahoma State University, the Missouri School Boards Association, the Missouri State Department of Elementary and Secondary Education, and the Oklahoma State Department of Education. *See* Comments of Midlands Consortium at 1.

[229] Courses include Basic English and Reading, Applied Economics, Advanced Placement Calculus, Chemistry, Physics, German, and Russian. *See id.* at 4.

[230] *See id.*; Putka, *Schools Giving TV Warmer Reception*, Wall St. J., Dec. 26, 1989, at B1. The Consortium also provides preparatory courses for college board examinations to some 60,000 students in 38 states, as well as instructional courses for more than 800 teachers in some 34 states. *See* Comments of Midlands Consortium at 5.

[231] Students submit homework and examinations by mail. *See* Putka, *Schools Giving TV Warmer Reception*, Wall St. J., Dec. 26, 1989, at B1. It is not unusual for there to be only a single student at a particular receiving site.

[232] *See id.*

[233] *See OTA Report*, *supra* note 174, at 16.

[234] *See id.* at 16-17. A similar project is the Kids Interactive Telecommunications Project by Satellite (KITES), an effort launched by a Massachusetts college professor to enable secondary school students to discuss important issues of the day with their peers from other nations. *See id.* at 34. Using Digital Equipment Corporation's existing international satellite network, KITES has conducted a 90-minute teleconference among students in three Massachusetts schools and students in West Germany to discuss environmental issues. In the future, KITES hopes to expand the number of state schools involved, expand its coverage to include museums, libraries, and community centers, and create links with nations other than Germany. The project's ultimate goal is "to give students the tools and knowledge they need to communicate in the global community that they will inherit." *See id.*

Increasingly, distance learning networks are using fiber optic cable. In Beaver County, Oklahoma, the Panhandle Shar-Ed Video Network Cooperative[235] has installed 52 miles of fiber optic cable to connect the county's four public high schools.[236] The network transmits two-way, full-motion video between and among the four schools, allowing students in any one classroom to communicate with classmates at every other location. Capital costs of the network totaled some $340,000, which includes the cost of the video equipment at each site, plus a five-year lease of the fiber transmission facilities owned and operated by Panhandle Telephone Cooperative.

The network has allowed the four schools to pool their limited faculty resources and offer courses (such as Advanced Placement English, art, Spanish, and accounting) that none could offer on a stand-alone basis.[237] The network has also made it easier for the schools to satisfy increased state accreditation requirements, and thus stave off the possibility that some or all of them might have to close down or consolidate.[238]

The State of Mississippi, Northern Telecom, BellSouth, IBM, and Apple Computers have implemented "Mississippi 2000," a pilot distance learning project designed to improve educational opportunities in the rural Mississippi Delta region of the state.[239] Fiber optic facilities from BellSouth's public switched network connect Mississippi State University in Starksville, the Mississippi University for Women in Columbia, the Mississippi School for Math and Science in Columbia, a Mississippi Educational Television Network studio in Jackson, and four high schools in the Delta area.[240] The network allows the four institutions to send simultaneously two-way, full motion instructional programming to any or all of the four high schools.

As a final example, Michigan Bell recently instituted a pilot program that will link six school facilities in Lansing-Jackson, Michigan, by a fiber optic network.[241] Each site will be equipped with video equipment (at a cost of about $22,000 per site) that will allow it to both transmit and receive two-way, full-motion video to and from any of the other sites. Among other things, this would free Potterville High School students from the 15-mile bus rides to Lansing Community College they now take to receive courses that the High School cannot provide.

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[235] The Cooperative comprises the four school districts in Beaver County (Beaver, Forgan, Balko, and Turpin) and Panhandle Telephone Cooperative, the LEC serving Beaver County. *See id.* at 36.

[236] *See* Reply Comments of Southwestern Bell Corp. at 8.

[237] *See id.* at 8-9; *OTA Report, supra* note 174, at 36-37. The network also allows the schools to provide inservice training to teachers, hold administrative meetings, and furnish community education programs for local residents.

[238] *See* Reply Comments of Southwestern Bell Corp. at 9-10.

[239] *See* Comments of Northern Telecom at 30; Comments of BellSouth Corp., App. B at 2-3. *See also* Clendenin, *Bringing Technology to the Classroom,* 126 Pub. Util. Fortnightly 18 (1990).

[240] *See* Comments of Northern Telecom at 30; Comments of BellSouth Corp., App. B at 2.

[241] Harry Semerjian, Director of Strategic Planning, Michigan Bell, personal communication (Jan. 1991). The (continued...)

3. Conclusions

Even this brief examination of distance learning confirms the widening consensus that telecommunications can be a powerful tool for delivering educational services to students of all ages and in all areas. Such applications can help students in small or poor school districts (rural and urban alike) to share in the educational opportunities available to their more fortunate peers. Distance learning can enable teachers in the most isolated areas to acquire and hone skills that will enhance the educational experience for their students. It can both allow colleges and universities to reach out to non-traditional student populations, and permit more citizens to experience the rewards of lifetime learning. Perhaps most important, it can help to breach the geographic barriers that have separated students in given local educational systems from more and better educational opportunities.

Distance learning raises a host of important issues, not all of them telecommunications-related. Although NTIA's focus is, of course, on the telecommunications policy aspects of distance learning, we believe that telecommunications policies intended to promote distance learning must be sensitive to the non-telecommunications issues surrounding distance learning to be effective. We, therefore, offer a few observations on these latter issues.

First, the available literature indicates that distance learning can be an effective tool for educating adults in nontraditional programs and for training professionals in business, industry, and the military.[242] Various types of distance learning approaches have been employed for some time in these settings, and research performed to date in this area

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[241] (...continued from preceeding page)
facilities are Lansing Community College, Jackson Community College, Potterville High School, East Lansing High School, Holt High School, and Ingham Intermediate School.

[242] *See OTA Report, supra* note 174, at 11 (citing Moore, *Effects of Distance Learning: A Summary of the Literature,* OTA Contractor Report (May 1989)).

suggests that, for many such students, distance learning can be as effective as face-to-face classroom instruction.[243]

However, distance learning applications are relatively new in traditional college programs and, in particular, in elementary and secondary school settings. More study is needed to determine under what conditions distance learning can be an effective tool for educating the primary and secondary school students who are now the targets of so many distance learning projects.[244] In the same vein, much more research is need to determine which instructional techniques and which distance learning applications convey knowledge to students most effectively. As OTA notes, the federal government could advance this process by providing research funding and by using its existing distance learning operations (*e.g.*, the DoDDS and BIA schools) as laboratories to explore new techniques, applications, and equipment.[245]

It is also important to acquaint all of our nation's schools with the power of telecommunications as an educational tool, so that the schools can use this tool in helping the nation meet its educational goals. As noted above, many U.S. schools have been largely untouched by the Information Age.[246] While more and more American schools are benefiting from distance education, most of the nation's 15,000 school districts and 100,000 schools either are unaware of those benefits or lack the facilities needed to capture them.

With respect to telecommunications policy issues, the examples discussed confirm that there is no single telecommunications technology that is best for distance learning applications in all circumstances.[247] Different projects have successfully employed different technologies. Indeed, several projects utilize a combination of available technologies. Moreover, although video applications are coming to be preferred in many distance learning projects,[248] other forms of distance learning can be cost-effective ways to convey knowledge to geographically dispersed students.[249] Further, because video images can be transmitted in a variety of different ways, telecommunications policy should not be structured in a way that denies educators the flexibility to select the technologies for their distance learning projects based solely on cost and pedagogical factors.[250] For example, as noted above, although the use of telecommunications facilities to provide distance learning has expanded rapidly in recent years, broadcasting has been and remains a powerful tool for providing educational programming.

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[243] *See, e.g.*, Ellerson, *Report on Distance Learning: A National Effectiveness Survey* (Dec. 1987).

[244] *See OTA Report, supra* note 174, at 26, 44-50.

[245] *See id.* at 19-20.

[246] *AMERICA 2000, supra* note 183, at 30.

[247] *See, e.g., OTA Report, supra* note 174, at 26; Comments of Midlands Consortium at 2; Comments of Kirkwood Community College at 6-7; Comments of CPB at 30-31.

[248] *See OTA Report, supra* note 174, at 26; Sally Johnstone, Director, Western Cooperative for Educational Telecommunications, personal communication (Feb. 1991).

Thus, the optimum configuration and ultimate potential of distance learning is as yet unclear. Yet, even when the future of these services is viewed through a glass darkly, the possibilities for telecommunications in education are manifest. As the projects discussed make clear, distance learning does not observe geographic boundaries. Thus, it can enrich the choices that educators and parents will have in designing public education for America's youth.[251]

Today, policies to enable students to attend the schools that they and their parents choose are being advocated widely. The Bush Administration has embraced choice of educational institution as a central plank of its national education strategy.[252] The National Governors' Association has endorsed increased choice in public education;[253] and citizens have endorsed such choice in survey after survey.[254]

In the past, geography has limited available educational choices even where bureaucratic obstacles were removed, because few parents are able to transport their children beyond nearby schools. Distance learning raises the possibility that students might continue traveling to the nearest school building, but use telecommunications to dial outward to an array of educational opportunities. But telecommunications can only help to unlock this potential, because institutional reforms are also required.

Widespread use of distance learning will require that educators wrestle with a host of contentious issues, such as teacher certification and evaluation, curriculum and textbook standardization, and class size. Interagency and intergovernmental coordination may be required to resolve these issues, and the federal government can potentially play an important role in facilitating that process.

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[249] *See* Ellerson, *Report on Distance Learning: A National Effectiveness Survey* (Dec. 1987); Sally Johnstone, Director, Western Cooperative for Educational Telecommunications, personal communication (Feb. 1991).

[250] *See* Comments of South Carolina DIRM at 7-14; Comments of INTV at 14-15; Comments of NAB at 9-11.

[251] *See* Comments of Kirkwood Community College at 9-10.

[252] *See AMERICA 2000, supra* note 183, at 12.

[253] *See* J. Chubb and T. Moe, *Politics, Markets and America's Schools* (1990).

[254] See *id.* at 306 n.29.

It is also important to keep in mind that many, if not all, of the distance learning applications discussed above have received substantial amounts of federal or state funding. As with many other education resources, if the United States is to reap the potential benefits of distance learning, such projects will need continued support from government agencies, particularly local school districts. Government at all levels currently pays for the costs of public education in this country. To the extent that distance education is a cost-effective way to deliver educational services, providing funding for it would represent a productive use of the monies now devoted to education.

In any event, government support for distance learning need not be expressed in the form of more funding. Rather, government can just as easily promote distance learning projects by helping to reduce the costs of the telecommunications facilities that make such projects possible. For example, in 1989, the Kansas Corporation Commission decided to allow regulated telephone carriers, on a case-by-case basis, to implement reduced "Economic Development Rates" for services provided to, among other things, educational organizations.[255] Similarly, pursuant to Section 396(h) of the Communications Act, the FCC may authorize common carriers to offer free or reduced rate interconnection services to public television and radio stations.[256] We recommend that Congress consider promoting distance learning by making such rate discounts equally available to distance learning projects.

B. HEALTH CARE

It is readily apparent why private and public health care providers are major potential users of telecommunications facilities and services. Provision of adequate health care depends, in a very fundamental sense, on the communication, acquisition, and processing of information by and between patients, health care professionals, and health care institutions. This linkage between information and health care is, indeed, pervasive. For example, the doctor-patient relationship, by its nature, rests on a communication between two individuals. It is during this conversation that the physician gathers information on the patient's vital signs, symptoms, and medical history that provide the basis for doctor's diagnosis and recommended course of treatment.

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[255] *See Davidson, supra* note 56, at 2.2.2.

[256] 47 U.S.C. § 396(h) (1988).

Easy availability of information can also promote greater and better prevention, health promotion, and self-care on the part of individuals, thus reducing pressures on the health care system. It has been estimated, for instance, that 80 percent of front-line health care decisions are made in the home.[257] In other words, in the vast majority of cases, diagnosis and treatment of illness or injury is made outside of the formal health care system. Additionally, between 40 and 70 percent of the causes of premature death in this country are preventable,[258] whether by change in diet, exercise habits, or lifestyle. Giving individuals access to reliable health information and health care decision support can help them to make sensible, informed choices that will safeguard their health and well-being.

Moreover, the health care system generates large quantities of medical records and other information that must be managed properly if adequate health services are to be provided in a cost-effective manner. For example, according to one study, administration expenses comprised between 19.3 and 24.1 percent of total U.S. health care costs in 1987, a 37 percent increase (in "real" terms) from 1983.[259] Thus, while information is critical to the provision of health services, coping with that information is one of the major challenges that health care providers face.

Given these fundamental linkages between information and health care, it is not surprising that the health care industry is actively exploring the use of telecommunications in the delivery of health services. Simply put, to the extent that telecommunications can facilitate acquisition, interchange, processing, and transmission of health and human services information, it promises to promote provision of higher quality services at lower costs.

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[257] *See* Office of Disease Prevention and Health Promotion, Public Health Service, U.S. Dep't of Health and Human Services, *Healthfinder: Family Care* at 1 (Feb. 1989).

[258] *See* Presidential Remarks at the Centennial Celebration of the Johns Hopkins University Medical Institutions in Baltimore, Maryland, 26 Weekly Comp. Pres. Doc. 290, 291 (Feb. 26, 1990).

[259] *See* Woolhandler and Himmelstein, *The Deteriorating Administrative Efficiency of the U.S. Health Care System,* 324 New England J. of Med. 1253 (1991).

1. Examples of Telecommunications and the Delivery of Health Care

a. *Using Telecommunications to Reduce the Administrative Costs of Providing Health Care*

The health care industry's growing affinity for so-called "telemedicine" applications[260] stems, in part, from the need to control spiraling health care costs. In 1989, total expenditures on medical care in the United States were about $613 billion, or some 11.6 percent of GNP.[261] As importantly, the cost of medical services increased by 99 percent between 1980 and 1989, twice as fast as the rate of inflation during this period.[262] Many current telemedicine projects focus on controlling these costs.

For example, in 1988, SNET and ProMed Systems, a subsidiary of Blue Cross and Blue Shield of Connecticut, deployed the nation's first statewide electronic insurance claims and medical management network.[263] Using SNET's local packet switched data services and software developed by ProMed, the network links together hospitals, doctors, and health care providers to facilitate, among other things, processing of insurance claims.[264] Blue Cross now receives 20 percent of its claims electronically via the network, which has greatly accelerated processing times, reduced errors, and saved the firm some $300,000 annually in administrative costs.

The Dartmouth Hitchcock Medical Center, the primary health care provider in the predominantly rural areas around Hanover, New Hampshire, has deployed a private network linking the Medical Center with smaller clinics in the surrounding region.[265] The network allows the clinics to perform administrative tasks such as patient scheduling, medical records tracking, purchasing, and billing through a centralized data processing facility in Hanover, thus enabling the clinics to treat patients more conveniently and at less cost. Another project at Dartmouth involves the development of interactive patient decision support systems. Early data indicate that patients informed through such systems are more prudent users of health care services.[266]

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[260] As the term suggests, "'telemedicine' refers to the application of telecommunications and information resources to the health field." *Davidson, supra* note 56, at 3.1.1.

[261] *See, e.g., CEA Report, supra* note 3, at 135, 286. We generated total health care expenditures by multiplying the 1989 U.S. GNP of $5,289.3 billion by 11.6 percent.

[262] *See id.* at 137.

[263] *See* Comments of SNET at 17.

[264] The Connecticut network is also connected to several medical databases, thus giving hospitals and doctors remote access to diagnostic and other medical information.

[265] *See* Comments of NYNEX Corp. at 43-44. The network is composed primarily of low-cost analog telephone lines, although the Medical Center is now employing some higher-cost 56 kbps and 1.5 Mbps digital lines as well.

An orthopedic clinic in a Philadelphia suburb uses satellite technology to transmit X-ray images to the University of Pennsylvania Hospital in the city.[267] Radiologists at the Hospital interpret the images, then consult with physicians at the clinic. Having remote access to the Hospital's radiology department saves the clinic from having to employ a full-time radiologist, thus reducing its costs in treating patients.

b. Using Telecommunications To Improve the Quality and Cost-Effectiveness of Health Care

The health care industry is also employing telecommunications to enhance the quality of health care. As noted above, broader dissemination of health and medical information can enable patients to better safeguard their health. At the same time, rapid advances in medical knowledge and technologies have increased demands on health care professionals to keep abreast with developments in medical research, new diagnostic and treatment procedures, new drugs, and the like.[268] The steady specialization of the medical profession has also increased the need for health care professionals to share their expertise with their colleagues and peers. To the extent that telecommunications can improve delivery of medical information to both practitioners and consumers, it can have a substantial beneficial effect on the quality of health care.

Individuals can now call a wide range of organizations via toll-free numbers to obtain health care information.[269] While these organizations do not diagnose or recommend treatment for any disease, they do provide recorded information, personalized counseling, referrals, or written information.[270]

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[266] *See* Office of Disease Prevention and Health Promotion, U.S. Dep't of Health and Human Services, Proceedings of the Secretary's Council on Health Promotion and Disease Prevention at 8-9 (July 24, 1991 meeting).

[267] *See* Comments of UCC at Exhibit 9.

[268] *See* Comments of Northern Telecom at 43; Comments of NTCA/OPASTCO at 13 and Attach. A. One 1987 study found that a typical hospital spent $1-2 million annually, or 3-7 percent of its annual operating budget, on staff training and education. Comments of Northern Telecom at 43 (citing a Boston Consulting Group study entitled *Opportunities in Health Care*).

[269] *See* Office of Disease Prevention and Health Promotion, Public Health Service, U.S. Dep't of Health and Human Services, *Healthfinder: Federal Health Information Clearinghouses* (Sept. 1990); Office of Disease Prevention and Health Promotion, Public Health Service, U.S. Dep't of Health and Human Services, *Healthfinder: Toll-Free Numbers for Health Care Information* (Jan. 1990).

In Memphis, Tennessee, three hospitals are using a fiber optic network to share computer and diagnostic equipment, including a Magnetic Resonance Imaging (MRI) machine.[271] The sharing of such limited, costly equipment enhances the diagnostic capabilities at each hospital. The high-capacity and high resolution afforded by the fiber optic tie-lines also allows treating physicians to review and analyze MRI images from any of the three locations. The potential improvements in the quality of patient care are obvious.

Telecommunications helps hospitals in the Bowling Green, Kentucky, area to provide better coronary care to their emergency room patients. The hospitals send EKG results via fax machines to cardiologists at the Bowling Green Medical Center.[272] After reviewing the EKG, a cardiologist can advise a physician in one of the surrounding hospitals on possible treatment, or can instruct him to transport the patient to the Medical Center's coronary care unit.

Further telemedicine applications are currently the subject of a number of pilot or demonstration projects. For example, Cardinal Glennon Children's Hospital in St. Louis and the University of Texas Health Sciences Center in Houston are conducting a six-month test in which they are using standard telephone lines to deliver X-ray and other images between themselves and to other locations.[273] A scanner converts an X-ray to a digital image and transmits it over a telephone line to another computer, which can restore the image, display it on a monitor, and then compress and store it.

In North Carolina, BellSouth, GTE, and the University of North Carolina Medical Center are developing a fiber optic network that will link a Cray supercomputer with one of the University's hospitals.[274] The computer will help better focus the hospitals laser equipment and, thus, aid the hospital in treating tumors in patients.[275] In Massachusetts, NYNEX is conducting trials of its network-based Media Broadband Service (MBS) with four Boston hospitals. The service will allow, for example, a physician to insert an ID card into a multi-media terminal and access, manipulate, or annotate information, including images, on any of his patients.[276] As importantly, the service will allow doctors at any of the four locations to consult with each other using voice, text, or images.

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[270] Radio and television broadcasters also greatly contribute to the dissemination of medical information to the American public through their programming and public service announcements on health care issues. *See* Comments of NAB at 11-12; Comments of INTV at 15.

[271] *See* Comments of BellSouth Corp., App. B at 12.

[272] *See id.*, App. B at 13.

[273] *See* Comments of Southwestern Bell Corp. at 19-20. Although Southwestern Bell notes that standard telephone lines are adequate to this task, it states that deployment of ISDN facilities would enhance delivery of images.

[274] *See* Comments of BellSouth Corp., App. B at 11-12.

The Harvard Community Health Plan, a large health maintenance organization, is currently designing a fully automated health center, which its members can access through a Minitel-type terminal. This arrangement will enable members to consult with their doctors by electronic mail, order prescriptions, and access a specially designed, consumer oriented health data base.[277] It will also permit physicians to respond electronically with appropriate advice on their patients' symptoms and questions and, where necessary, make appointments online. The system will both help doctors maintain more effective contact with their patients and encourage and facilitate preventative health care on the part of patients.

c. Using Telecommunications To Provide Health Care in Underserved Areas

Finally, some health care providers are using telecommunications to improve the provision of medical services in underserved areas. Since 1980, over 200 rural hospitals have closed and one-fifth of the remaining institutions are at risk of closing.[278] Not only do rural areas face chronic shortages in health care professionals,[279] but the average rural hospital is also a generation or more behind its urban counterparts in terms of its diagnostic technologies.[280] Many inner city hospitals are in similar straits.[281] Many in the health care industry see telecommunications as a tool for improving delivery of medical services to those underserved areas.

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[275] Eventually, a broadband switch could be used to connect the supercomputer with other hospital locations, even outside of North Carolina.

[276] *See* Comments of NYNEX Corp. at 45.

[277] *See* Comments of CIRI at 2-3.

[278] *See Better Health Care for Rural America: Hearing Before the Joint Economic Comm.*, 101st Cong., 1st Sess. 1 (1989) (statement of Rep. Hamilton).

[279] In 1985, for example, metropolitan areas had nearly twice as many primary care physicians per 100,000 population as counties with fewer than 10,000 people. *See id.* at 20, 29 (statement of Tim Size, Executive Director, Rural Wisconsin Hospital Cooperative). *See also* Comments of NYNEX Corp. at 41-42; Comments of NTCA/OPASTCO, Attach. A at 3.

[280] *See Better Health Care for Rural America: Hearing Before the Joint Economic Comm.*, 101st Cong., 1st Sess. 65 (1989) (statement of Jeffrey C. Bauer, President, The Bauer Group).

[281] *See id.* at 20, 23 (statement of Tim Size, Executive Director, Rural Wisconsin Hospital Cooperative).

As described in the Notice, Texas Tech University in Lubbock, Texas, has allocated $4.4 million to the establishment of a "medical telecommunity" with three networks linking the University's health sciences centers to remote West Texas communities.[282] The first network, KARENET, combines standard telephone lines, computers, and software to give rural hospitals and clinics access to health care research, records, computer conferencing, and patient management.[283] Through the network, the University hopes to provide continuing education services to health care professionals in West Texas, as well as enable such professionals to consult with medical specialists and subspecialists at the University's health care centers.

The second network, INTERNET, is a satellite-based teleconferencing system that will link rural hospitals to Texas Tech's four campuses.[284] The third network, MEDNET, is a satellite-based, two-way interactive video system connecting rural doctors with specialists at the Texas Tech health sciences centers.[285] Among other things, the network will be used to explore the cost effectiveness of remote patient examination and consultation, and transmission of high quality medical images.[286] It will also provide continuing education to rural doctors and nurses in the form of conferences and workshops.

In North Dakota, fiber optic facilities are being used to deliver instructional programming in nursing and medical technology to students in rural areas, in order to train displaced farmers and other unemployed rural workers for careers in health care.[287] Finally, the U.S. Department of Health and Human Services and the Microelectronics and Computer Technology Corporation have recently supported the work of researchers at the Baylor College of Medicine to develop a "community services workstation" and associated network to permit human service professionals to combine efficient information management with interactive video and teleconferencing.[288]

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[282] *See* Notice, 55 Fed. Reg. at 805, para. 42. *See also Davidson, supra* note 56, at 3.1.2; Comments of UCC at Exhibit 12a.

[283] *See Davidson, supra* note 56, at 3.2.1.

[284] *See id.* at 3.1.2.

[285] *See id.* at 3.1.2.

[286] *See* Comments of UCC, Exhibit 12a at 1-2.

[287] *See* Comments of NTCA/OPASTCO at 13 and Attach. A at 3.

2. Conclusions

The foregoing examples indicate the ways in which telecommunications can improve delivery of health care services.[289] Given the relatively undeveloped state of telemedicine, it is too soon to say which applications and serving arrangements will be most cost effective in meeting the needs of health care professionals and their patients. However, it is certain that telemedicine will continue to grow in scope and importance to the health care industry as the years go by. How rapidly telemedicine will begin to realize its potential is an open question.

Deloitte and Touche presents a reasonable "roll out" scenario that describes how New Jersey hospitals' demand for advanced telecommunications capabilities over the next ten years could require major changes in that state's public switched network.[290] Under this scenario, for the next several years hospitals would likely concentrate on developing and improving their existing automated medical record keeping systems, with particular emphasis on areas such as patient care and materials/supply management. As with the case of the ProMed system in Connecticut,[291] hospitals would begin to establish links with health insurers for the interchange of patient and claims information that will speed up claims processing and transfer of payments from insurers to hospital.[292] Initially, connections between hospital and insurer would probably require only the low-speed data links that are now readily available from the public switched network.[293] However, as those connections become more complex and widespread, the transport requirements for the public network would grow to accommodate more sophisticated needs.[294]

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[288] *See* Office of Disease Prevention and Health Promotion, U.S. Dep't of Health and Human Services, Proceedings of the Secretary's Council on Health Promotion and Disease Prevention at 6-7 (July 24, 1991 meeting).

[289] Expanded use of telecommunications to provide medical services increases the need for reliable telecommunications facilities and networks. Clearly, reliability concerns are critical when a service outage or failure can have life-threatening consequences. Moreover, more extensive transmission of patient information via telecommunications will necessitate greater care on the part of health care providers to ensure the privacy and accuracy of the information transmitted.

[290] *See Deloitte and Touche Study, supra* note 27, Vol. III, at VII-22 to VII-29.

[291] *See supra* notes 263-264 and accompanying text.

[292] *See Deloitte and Touche Study, supra* note 27, Vol. II, at VII-24 to VII-25.

[293] *See id.*, Vol. II, at VII-22.

In the mid-1990s, LANs would be deployed in many hospitals to facilitate rapid transfer and sharing of information among the various units of each hospital.[295] These networks would be particularly useful in managing transmission, storage, and retrieval of X-rays and other medical images. At the same time, economic considerations would compel hospitals to establish communications links with other hospitals, outpatient referral centers, and physicians offices.[296] Interconnecting the various high-speed LANs would require increasing capacity and flexibility on the part of public and private telecommunications facilities.

Finally, hospitals would continue to explore the use of telecommunications to provide continuing education and training for health care professionals,[297] as well as to permit remote audio and video consultations between physicians.[298] Although many of these applications would rely heavily on satellite transmissions, as is the case in many current projects,[299] their success would likely stimulate demand for advanced capabilities, such as switched broadband.[300]

Because telemedicine applications are still evolving, it is difficult to know now precisely what telecommunications capabilities are or will be needed to support them. Moreover, as was the case with respect to distance education, there appears to be no single telecommunications technology or network configuration that is best for all telemedicine services. Where telecommunications facilities are being used to connect a large medical center with surrounding hospitals and clinics, so as to extend or improve medical service to underserved areas, the benefits may generally outweigh the costs. Similarly, because many home-based health care services require fairly low transmission speeds,[301] their significant benefits can probably be obtained without substantial costs. However, if a telemedicine application involves deployment of high capacity facilities to many locations, so as to permit, for example, transmission of medical images to radiologists' homes,[302] the cost/benefit analysis becomes more difficult, especially for deployments in the near term.

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[294] *See id.*

[295] *See id.*, Vol. II, at VII-25.

[296] *See id.*, Vol. II, at VII-26 to VII-27. For example, connections with doctors will enable the hospital to provide physicians with valued administrative and diagnostic support. In return, the doctors may be willing to refer more of their patients to the supporting hospitals for treatment. *See id.*, Vol. II, at VII-27.

[297] It has been estimated that one-half of a health care professional's knowledge becomes outdated within five years. *See id.*, Vol. II, at VII-27.

[298] *See id.*, Vol. II, at VII-27 to VII-28.

[299] *See supra* notes 267 and 282-286 and accompanying text.

[300] *See Deloitte and Touche Study, supra* note 27, Vol. II, at VII-22.

[301] *See* Comments of Northern Telecom at 44.

Scientific and technological progress has dramatically improved the quality of health care for many patients in the United States, particularly with respect to the prevention, diagnosis, and treatment of diseases and injuries.[303] But for many other Americans those same services are either unavailable or not available in time. Meanwhile, the cost of health care in this country has soared, and the United States still lags behind other industrialized nations in several important public health indices. For example, the United States now ranks 22nd among developed countries in infant mortality rates.[304] Life expectancies at birth for both U.S. men and women are lower than those prevailing in four of our major trading partners, France, Japan, Germany, and the United Kingdom.[305]

To the extent that telecommunications can extend the benefits of quality medical care to more Americans and reduce the cost of good health, it should do so sooner rather than later. The 11.6 percent of the GNP that goes into medical services is a measure of the value that Americans attach to health, but such massive, continuing costs also signal a time-sensitive need for increased efficiency.

We do not yet know to what exact extent, or in precisely which ways, the telecommunications infrastructure can best address those needs. However, to the extent that an advanced infrastructure is made available for health care and other purposes, it can provide an avenue for creative solutions and effective collaborations. Those kinds of benefits need not await the distant future.

At the same time, government should craft telecommunications policies that allow maximum, continuing flexibility for users like health care providers, consistent with timely deployment of essential new telecommunications services and facilities.

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[302] *See, e.g., id.* at 42.

[303] *See, e.g., CEA Report, supra* note 3, at 135.

[304] *See* Presidential Remarks at the Centennial Celebration of the Johns Hopkins University Medical Institutions in Baltimore, Maryland, 26 Weekly Comp. Pres. Doc. 290, 291 (Feb. 26, 1990).

[305] *See* Comments of AHTUC, Attach. A at 37-38.

Telecommunications can help to lower the cost and improve the quality of medical care, but the value of its contribution will depend primarily on the resourcefulness of health care professionals and other end users.

V. QUALITY OF LIFE

While telecommunications holds the promise of boosting the performance of the U.S. economy and improving delivery of critical services, it can also be used to enhance the quality of life in the United States. In this section, NTIA will consider two such applications. The first, so-called "telecommuting," involves the use of telecommunications services to enable people to work at home, thus potentially freeing up time to devote to other activities and responsibilities. The second entails the use of telecommunications to permit persons with disabilities to share in the many economic and social opportunities available to other Americans. After examining each application in some detail, we will evaluate their implications for telecommunications policymaking.

A. TELECOMMUTING

As noted above, telecommuting involves, broadly speaking, the use of telecommunications to enable people to work at home. Under this general heading, however, more precise definitions of the term vary considerably.[306] As a result, reliable, consistent estimates of the number of telecommuters are hard to come by. It appears, nevertheless, that the number is both significant and growing rapidly.[307] A recent study found that nearly 35 million people in the United States (primarily self-employed or entrepreneurial individuals) worked at home in 1990, a 29 percent increase over the previous year.[308] However, some 3.6 million employees with full-time, commutable jobs worked at home at least one day per week in 1990, up 21 percent from 1989.[309] Between 350 and 500 U.S. employers—including both large and small businesses, as well as federal and state government agencies—now have formal telecommuting programs.[310]

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[306] For example, one definition of telecommuting might include all persons—including self-employed people—who work at home at least some of the time, since the availability of telecommunications services, to some degree, allows them to do so. *See* Comments of Southwestern Bell Corp. at 22. On the other hand, some definitions "consider only full time home workers, while others include employees whose companies do not formally allow employees to work at home but informally permit such arrangements." *See* Comments of Ameritech, App. A at 6.

[307] *See, e.g.*, Spayd, *Increasingly in Area, Home is Where the Workplace Is*, Wash. Post, Apr. 22, 1991, at A1 (*Spayd*).

[308] *See* Strazewski, *Sidestepping Rush-Hour Crush; Phones, Faxes, PCs Let Workers Operate at Home*, Crain's Chicago Business, Oct. 8, 1990, at T1 (*Strazewski*).

1. Government Interest in Telecommuting

Federal and state government officials are becoming increasingly aware that the potential benefits of telecommuting extend far beyond the workplace.[311] President Bush has pointed out, for instance, that if only five percent of the commuters in Los Angeles county would telecommute one day a week, they would keep 47,000 tons of pollutants from entering the atmosphere.[312] California employers are aggressively exploring telecommuting as a way to help them comply with the state's tightened air quality standards, which penalize employers for not encouraging their workers to ride-share, take public transportation, or otherwise reduce their office commutes.[313]

Telecommuting can also serve as an effective instrument of transportation and energy policy.[314] For example, a study by Arthur D. Little, Inc. (ADL) estimates that substituting telecommunications for certain transportation activities could save the U.S. economy some $23 billion annually (measured in 1988 dollars).[315] Most of these savings represent the avoidance of productivity losses that currently result from business travel and traffic congestion.[316] ADL also projects significant benefits from reductions in energy consumption and pollution. The potential benefits of telecommuting for transportation policy have piqued the interest of government officials. Thus, to reduce traffic congestion, the San Diego Association of Governments has devised a transportation management plan that requires firms with more than 50 employees to encourage workers to stop driving alone to work.[317] The plan suggests telecommuting as one way for firms to comply with these requirements. Similarly, in announcing his national transportation policy, President Bush asserted that "sometimes the best transportation policy means not moving people, but moving their work . . . commuting to work at the speed of light."[318]

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[309] *See id.*

[310] *See* Comments of NYNEX Corp. at 50-51. Employers with formal telecommuting programs include JC Penney, Levi Strauss, General Electric Plastics, US West, AT&T, Xerox, American Express, the U.S. Office of Personnel Management, and the California Public Utilities Commission. *See* Notice, 55 Fed. Reg. at 806, para. 47; *Strazewski, supra* note 308, at T1.

[311] *See, e.g., Spayd, supra* note 307, at A15.

[312] Presidential Remarks at the California Chamber of Commerce Centennial Dinner in Los Angeles, 26 Weekly Comp. of Pres. Doc. 338, 339 (Mar. 1, 1990). This limited telecommuting would also save 205 million miles of travel each year, which would not only save time for the employees involved, but would also reduce traffic congestion and energy consumption by the vehicles involved. *See id.* at 339. *See generally infra* notes 314-320 and accompanying text (discussion of the transportation and energy policy implications of telecommuting).

[313] *See Strazewski, supra* note 308, at T1; Comments of NYNEX Corp. at 53.

[314] One Virginia lawmaker has called for a state study on telecommuting, saying that its ultimate impact on traffic patterns could be more profound than more publicized transit initiatives. *See Spayd, supra* note 307, at A15.

[315] Arthur D. Little, Inc., *Can Telecommunications Help Solve America's Transportation Problems?* 19 (May 1991).

The significance of telecommuting for energy policy stems from the fact that, according to one study, some 25 percent of all U.S. motor fuel consumption and 11 percent of our total petroleum consumption in 1979 were attributable to the commute from home to work and back.[319] If greater reliance on telecommuting permits even a small reduction in the number of those commutes, the United States could realize substantial energy savings and, thus, limit our dependence on imported oil. Recognizing this, the Administration has made telecommuting a part of its national energy strategy. Specifically, the Administration proposes to spend $92 million dollars on "R&D and other investments to improve the interconnection of networks and enhance the capabilities of digital data," so as to promote greater use of telecommuting, although it has not specified when that money should be appropriated or how it should be spent.[320]

2. Benefits of Telecommuting in the Workplace

For employees, the benefits of telecommuting are readily apparent. At the most basic level, telecommuters can reduce both their daily commuting time (which averages about one hour per day) and their incidental expenditures for work-related transportation, food, and clothing.[321] Telecommuting can also help parents with children (particularly mothers) to balance work with child care. Moreover, it can create or expand job opportunities for persons with disabilities, elderly Americans, and residents of rural areas.

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[316] *See id.* at 20-21. Other savings are attributable to reduction in pollution, energy savings, and lower maintenance costs for the transportation system.

[317] *See* Comments of Ameritech, App. A at 8.

[318] Presidential Remarks at the National Transportation Policy Meeting, 26 Weekly Comp. Pres. Doc. 383, 384 (Mar. 12, 1991).

[319] *See Bellcore Study,* supra note 37, at 14.

[320] *See* U.S. Dep't of Energy, *National Energy Strategy* 138-139 (Feb. 1991). Such investments "will do much to build and improve the broadband transmission networks, powerful and inexpensive desktop workstations, easy-to-use software, and extensive remotely accessible data bases necessary for telecommuting." *Id.* at 139.

Employers, too, can garner substantial benefits by promoting telecommuting. By permitting employees to work at home, a firm can retain skilled, highly valued workers who wish to change their work schedules to accommodate other interests or demands.[322] It can also enable companies to reach untapped pools of highly qualified workers, such as women with small children and individuals with disabilities, who otherwise would not or could not readily commute to work.[323] Because the U.S. labor force will grow more slowly over the next decade, a firm's ability to attract and retain such employees will be critical to its ability to compete in the marketplace.

Telecommuting can also help a firm reduce its operating costs. Companies with cyclical sales, such as insurance or catalog shopping firms, can employ home-based workers to handle peak periods and thus avoid the expenses of a permanent, but periodically underutilized, staff.[324] Additionally, allowing employees to work at home can help a company reduce its overhead expenditures for office space, furniture, and electricity.[325]

Although telecommuting can benefit the nation in a variety of ways, questions arise about what sorts of telecommunications facilities and services must be available to make effective telecommuting possible. On the one hand, it is clear from the recent initiation of telecommuting programs by many employers that current telecommunications technology can support significant telecommuting applications.[326] On the other hand, it also seems clear that improved network capabilities would increase the types and scope of work that could be performed at home and, thus, enhance opportunities for telecommuting. Some commenters go so far as to assert, for example, that user-friendly broadband capabilities are a "virtual necessity" for telecommuting to become a truly attractive option for most companies and workers.[327] In the next section, we will examine a number of work-at-home programs and experiments to determine whether they offer any insights into this important issue, as well as into the benefits of telecommuting generally.

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[321] *See Bellcore Study*, supra note 37, at 14; Comments of Ameritech, App. A at 7.

[322] *See* Comments of Southwestern Bell Corp. at 24. In the same vein, government employers are increasingly viewing the option of working at home as a recruiting device to enable them to compete with private sector compensation packages. *See* Comments of NYNEX Corp. at 52.

[323] *See* Costello, *Home-Based Employment: Implications for Working Women* 11-12 (1987) (*Costello*); *Bellcore Study, supra* note 37, at 13.

[324] *See Costello, supra* note 323, at 12; Comments of NYNEX Corp. at 54.

[325] *See Costello, supra* note 323, at 12. These savings can be considerable; the average employee requires 100-200 square feet of office space at a total cost of about $1,500-6,000 per year. *See* Comments of Ameritech, App. A at 6.

[326] *See Preparing for the Office of Tomorrow*, Daily Telegraph, Oct. 14, 1990, at 29; Kay, *Remember That Old Saying About the Best Defense?*, ComputerWorld, Aug. 20, 1990, at 65.

3. Examples of Telecommuting Programs

Although telecommuting is now rapidly gaining favor among U.S. employers, it is not a new phenomenon. In 1981, IBM viewed telecommuting as a way to attract and retain qualified workers and, thus, help the company cope with anticipated future shortages of computer scientists and electrical engineers.[328] A trial involving 300 computer programmers established that home-based workers were more productive and that IBM could manage logistics and security. IBM then launched a wide-scale telecommuting program in 1983. The company ultimately paid telephone line, modem, and terminal equipment costs for more than 8,000 employees working at home.

In 1987, Traveler's Insurance commenced a pilot telecommuting program involving 10 employees. The program now has more than 100 participants, each of whom is connected to the company's headquarters via a dedicated packet switched access line. The company's work-at-home program has enabled it to retain top performing data processing and other computer operators in a tight labor market.[329] Traveler's has also found that the $4,000 investment required to provide each worker with a home work station is more than offset by savings in office space and increased productivity.[330]

Ciba-Geigy, an international chemical company with U.S. offices, currently has a telecommuting program, primarily for its information systems personnel. Among other things, the program has allowed employees to remain with the company even after they had relocated to the District of Columbia and Florida.[331] The program has also produced substantial dividends for Ciba-Geigy in the form of increased employee loyalty and productivity.

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[327] *See* Comments of Contel Corp. at 18. *See also* Comments of NYNEX Corp. at 54-55.

[328] *See Bellcore Study, supra* note 37, at 13.

[329] *See Deloitte and Touche Study, supra* note 27, Vol. II, at V-15.

[330] *See* Kay, *Remember that Old Saying About the Best Defense?*, Computer World, Aug. 20, 1990, at 65.

[331] *See* Comments of NYNEX Corp. at 54-55.

In the Watts section of Los Angeles, the JobLink program, a consortium of non-profit community agencies and Pacific Bell, uses telecommuting to provide computer training to people often considered unemployable. Instead of traveling to employer locations, participants perform data entry and word processing operations in neighborhood work centers, then send finished work to clients over the public network. In its first year, the program trained and employed over 40 people.[332]

Blue-Cross/Blue-Shield of South Carolina has instituted a work-at-home program for some of its data entry personnel, who use computer terminals and telecommunications lines to access the company's central computer facility. The firm has found that the productivity of its telecommuting employees has increased 50 percent.[333] Control Data Corporation has a similar program for about 100 of its employees (primarily computer programmers), and has seen productivity gains of some 35 percent.[334]

Bell Atlantic recently initiated a six-month telecommuting trial involving 50 management workers at its Arlington, Virginia, network services headquarters. The employees (including some supervisors) will work up to 3 days per week at home. The company will supply personal computers, modems, and fax machines to those home-based employees without such equipment. Bell Atlantic will study not only telecommuting's impact on productivity, but also what products and services are needed to make telecommuting a potential business opportunity for the company.[335]

The California Department of General Services recently completed a two-year trial telecommuting project that encompassed 150 employees from several state agencies.[336] Each agency involved decided whether to supply needed equipment to its telecommuting workers. Some agencies required their workers to buy personal computers; others supplied that equipment if the employee agreed to work at home three or more days per week. The final report on the project concluded that telecommuting had proven beneficial in several respects. Most importantly, the productivity of the home-based employees exceeded that of a non-telecommuting control group.[337] Moreover, telecommuting improved the quality of employees' lives, lowered costs for office and parking spaces, and showed significant potential for reducing traffic congestion, air pollution, and energy usage. Finally, the agency found that implementation of an effective work-at-home program did not require major capital investments.

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[332] *See Deloitte and Touche Study, supra* note 27, Vol. II, at V-11.

[333] *See id.*, Vol. II, at V-19.

[334] *See id.*

[335] *See* Telecommunications Reports, Feb. 4, 1991, at 21.

[336] *See* Hildebrand, *Who Bears the Burden?*, ComputerWorld, July 16, 1990, at 43.

Other government agencies are also implementing or considering telecommuting projects. The Washington State Energy Office is now conducting a Telecommuting Demonstration Project involving 23 public and private employers and some 250 telecommuters.[338] The agency will compare the performance of these home-based employees with a non-telecommuting control group, as well as assess the effects of telecommuting on traffic, air quality, and energy use. The Hawaii legislature has appropriated $125,000 (to be matched by private funds) to establish the Hawaii Telework Center, a centralized facility from which public and private sector employees are linked via telecommunications to their offices.[339] The State Department of Transportation estimates that each of the 17 workers now using the Center will drive 9,000 fewer miles, save 350 gallons of gasoline, and avoid $2,500 in automotive expenditures each year.[340] Employers also report an increase in productivity and employee loyalty.

4. Conclusions

The foregoing discussion indicates that greater use of telecommuting can generate unquestionable economic and social benefits for U.S. businesses and citizens. For workers, telecommuting can significantly reduce the time consumed and stress produced during the ride to work, thus increasing job satisfaction and giving them time for other interests and responsibilities. At the same time, telecommuting can help employers reduce operating costs and better attract and retain skilled workers. As importantly, the available evidence suggests that telecommuting employees are as productive—indeed, in many cases, more productive—than their office-bound colleagues.[341]

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[337] *See* Gordon, *Telecommuting Review,* July 1, 1990, at 1.

[338] *See* Washington UTC, *The 1991 Report on the Status of the Washington State Telecommunications Industry* 12 (Feb. 15, 1991).

[339] *See* Comments of the State of Hawaii, App. B at 1.

[340] Each employee's average daily commute time will also be 2 1/2 hours shorter.

[341] In the words of President Bush, "[m]illions have already found their productivity actually increases when they work nearer the people they're really working for: their families at home." Presidential Remarks at the National Transportation Policy Meeting, 26 Weekly Comp. Pres. Doc. 383, 384 (Mar. 12, 1991).

There are, nevertheless, important barriers to more widespread use of telecommuting by companies and their workers. At the most basic level, many jobs cannot readily be performed from home.[342] For example, a 1977 study estimated that only about 50 percent of white collar employees (then, about 26 million workers) could work effectively from home.[343] Moreover, some employers may be slow to implement a telecommuting programming because of insecurities about supervision, instruction, and quality control.[344] For employers and employees alike, telecommuting may not have desirable characteristics of the traditional office environment, such as interaction among co-workers, socialization of new workers into the company culture, and mechanisms for allocating time.[345]

Finally, although the current capabilities of the domestic telecommunications infrastructure are clearly sufficient to support substantial telecommuting activities, further development of that infrastructure could permit even more extensive work-at-home programs. Many of the telecommuting programs discussed, for example, involve data entry and computer processing, which have relatively simple telecommunications requirements. Performance of other tasks at home, including knowledge-intensive tasks such as interactive computer-aided design or remote software testing, may require far more advanced telecommunications capabilities, such as simultaneous voice and data transmission, high capacity data transmission, or two-way transmission of high resolution images.[346] Accordingly, although the current growth of telecommuting projects is certainly encouraging, telecommunications providers, business customers, and potential telecommuters should continue to plan for even more advanced possibilities for telecommuting.

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[342] *See Bellcore Study, supra* note 37, at 12.

[343] *See id.*

[344] *See* Comments of Ameritech, App. A at 6; *Costello, supra* note 323, at 11. *See also Spayd, supra* note 307, at A15 (biggest issue in telecommuting is overcoming the resistance of managers who believe that "if you can't see someone, they must not be working").

[345] *See Costello, supra* note 323, at 11.

[346] *See, e.g.*, Comments of NYNEX Corp. at 55-56.

B. TELECOMMUNICATIONS AND THE DISABLED

Today, there are some 43 million Americans with some form of physical or mental disability.[347] Statistics consistently show that these disabled Americans do not share the economic and social opportunities that are widely available to their fellow citizens. For example, a 1986 survey found that two-thirds of all disabled persons between the ages of 16 and 64 were unemployed, even though the bulk of those questioned said they wanted to work.[348] Census Department statistics reveal that 40 percent of all adults with disabilities did not finish high school, more than three times the rate for nondisabled individuals.[349] Moreover, when disabled Americans do find jobs, they are generally less well-paid than nondisabled workers.[350] Because of this, in 1984, 50 percent of all disabled adults had household incomes of $15,000 or less, roughly twice the rate for nondisabled adults.[351]

There is now virtually universal agreement that the United States must put an end to "the unjustified segregation and exclusion of persons with disabilities from the mainstream of American life."[352] This new attitude stems in part from the understanding that giving disabled Americans access to the economic, educational, and social opportunities enjoyed by their fellow citizens can have benefits far beyond those reaped by the disabled themselves. It will also allow businesses to tap a large pool of capable, motivated workers, thus alleviating shortages in the labor force projected for the coming decade.[353] For government, expanding employment opportunities for disabled workers means both increased tax revenues and reduced costs for social support programs.[354]

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[347] *See* Americans with Disabilities Act of 1990, Pub. L. No. 101-336, § 2(a)(1), 104 Stat. 327, 328. This number is expected to grow because the U.S. population as a whole is growing older.

[348] *See* H. Rep. No. 485(II), 101st Cong., 1st Sess. 32, *reprinted in* 1990 U.S. Code Cong. & Admin. News 314 (H. Rep. No. 101-485(II)) (citing Louis Harris and Associates, *The ICD Survey of Disabled Americans: Bringing Disabled Americans Into the Mainstream* (1986)). In absolute terms, this means that 8.2 million disabled persons want to work, but cannot find a job. *See id.*

[349] *See id.* (citing Bureau of the Census, U.S. Dep't of Commerce, *Labor Force Status and Other Characteristics of Persons with Work Disabilities: 1981-88* 2 (July 1989)).

[350] In 1988, disabled men and women earned 36 percent and 38 percent less, respectively, than their nondisabled counterparts. *See id.* (citing Bureau of the Census, U.S. Dep't of Commerce, *Labor Force Status and Other Characteristics of Persons with Work Disabilities: 1981-88* 5 (July 1989)).

[351] *See id.* (citing Bureau of the Census, U.S. Dep't of Commerce, *Labor Force Status and Other Characteristics of Persons with Work Disabilities: 1981-88* 2 (July 1989)).

[352] Presidential Statement on Signing the Americans with Disabilities Act of 1990, 26 Weekly Comp. Pres. Doc. 1165, 1166 (July 30, 1990).

We believe that telecommunications can and should play a major part in bringing disabled citizens into the mainstream of American life. Indeed, using telecommunications to create opportunities for the disabled would help remedy an historical irony associated with development of the telephone. That remarkable device resulted, in part, from Alexander Graham Bell's efforts to assist the deaf.[355] As the telephone became an increasingly essential part of business and personal life for hearing Americans, hearing-impaired people were increasingly disadvantaged. Thus, the fruits of research first intended to open the world to hearing-impaired people only enlarged their isolation from it. It is therefore fitting that, at long last, the telephone and the telecommunications system should become a device for both liberating and empowering hearing-impaired and other disabled Americans.

To date, much of the government effort to enhance the usefulness of telecommunications for the disabled has focused on Americans who suffer from hearing or speech impairments.[356] In 1982, Congress ordered the FCC to adopt regulations requiring that all "essential telephones" be made hearing aid compatible.[357] In 1988, Congress amended this legislation to require that most telephones manufactured in the United States or imported for use in the United States be hearing aid compatible by August 16, 1989.[358]

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[353] *See, e.g.,* Comments of NYNEX Corp. at 62.

[354] *See id.*; Americans with Disabilities Act of 1990, Pub. L. No. 101-336, § 2(a)(9), 104 Stat. 327, 329. The total national costs for disabilities has been estimated at over $170 billion. *See* Comments of NYNEX Corp. at 57 (citing Bowe, *Recruiting Workers with Disabilities,* Worklife (Summer 1989)).

[355] *See* G. Brock, *The Telecommunications Industry: The Dynamics of Market Structure* 90 (1981) (*Brock*).

[356] *See* H. Rep. No. 101-485(II) at 129, 1990 U.S. Code Cong. & Admin. News at 412.

[357] *See* The Telecommunications for the Disabled Act of 1982, Pub. L. No. 97-410, § 3, 96 Stat. 2043 (codified at 47 U.S.C. § 610 (1988)). The Act defined "essential telephones" as "coin-operated telephones, telephones provided for emergency use, and other telephones frequently needed for use by persons" with hearing aids. *See* 47 U.S.C. § 610(b)(4)(A).

The FCC regulations implementing the Act appear at 47 C.F.R. §§ 68.4, 68.112 (1990). The FCC has extended the definition of "essential telephones" to include all credit card telephones and telephones in common areas of the workplace. *See Access to Telecommunications Equipment and Services by the Hearing Impaired and Other Disabled Persons,* 5 FCC Rcd 3434 (1990), *recon. denied,* 6 FCC Rcd 4799 (1991).

[358] *See* The Hearing Aid Compatibility Act of 1988, Pub. L. No. 100-394, 102 Stat. 976 (codified at 47 U.S.C. § 610(b)(1)(B) (1988)). Telephones manufactured in the United States for export need not be hearing aid compatible.

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The federal government and the states have also taken action to enhance the usefulness of the equipment that hearing and speech-impaired people use in lieu of telephones (so-called Telecommunications Devices for the Deaf, or TDDs).[359] Although TDDs can expand such persons' access to the outside world, the devices are nevertheless limited because TDD-generated signals can only be received by another TDD. As a result, deaf or mute people, even if they have TDDs, often cannot communicate with nondisabled persons via the telephone network.

To alleviate this problem with respect to intrastate calls, 19 states have established TDD relay systems,[360] and 10 more are expected to institute them by the end of 1991.[361] In 1986, the federal government implemented a government-wide demonstration TDD system that allowed federal employees with TDDs to communicate with the non-hearing-impaired, and TDD users to communicate with non-hearing-impaired government employees.[362] In 1988, Congress directed the FCC to make this network permanent.[363] Finally, in 1990, the Americans with Disabilities Act required all common carriers providing telephone services to implement TDD relay systems that comply with FCC-prescribed standards by July 26, 1993.[364]

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[359] A TDD is a teletypewriter device equipped with a message display screen. The device converts typed characters into a coded signal that is then passed over the telephone network via a standard voice circuit. *See Access to Telecommunications Equipment and Services by the Hearing Impaired and Other Disabled Persons,* 4 FCC Rcd 6214, 6235 n.3 (1989).

[360] In a TDD relay system, "a TDD user speaks or types a message to a relay operator, who uses a video display system to forward the spoken or typed message between the hearing-impaired TDD user and the voice telephone user." H. Rep. No. 100-1058, 100th Cong., 2d Sess. 2, *reprinted in* 1988 U.S. Code Cong. & Admin. News 3596, 3597. Conversely, the operator converts a voice message into a TDD signal for transmission to the hearing-impaired party.

[361] *See* H. Rep. No. 485(II) at 39, 1990 U.S. Code Cong. & Admin. News at 321. TDD relay systems are under consideration in an additional eight states. *See* Notice, 55 Fed. Reg. at 806, para. 51 (citing The National Center for Law and the Deaf, *Dual Party Relay Systems* (July 1989)) (TDD relay systems have been adopted or are under consideration in 37 states).

[362] H. Rep. No. 1058, 100th Cong., 2d Sess. 2, *reprinted in* 1988 U.S. Code Cong. & Admin. News 3596, 3597. This relay system consisted of two TDDs, two answering machines, one printer, and one relay operator, and handled an average of 537 calls per month. About 45 different federal agencies installed TDDs. The annual operating cost of the network was $17,289. *See id.* at 3, 1988 U.S. Code Cong. & Admin. News at 3597-3598.

[363] *See* Telecommunications Accessibility Enhancement Act of 1988, Pub. L. No. 100-542, § 3(b)(1), 102 Stat. 2721. The Act also requires the FCC to maintain and publish a directory of TDD equipment used by the federal government and the access numbers for those devices. *See id.* § 3(b)(5).

[364] *See* Americans with Disabilities Act of 1990, Pub. L. No. 101-336, § 401(a), 104 Stat. 366-368 (to be codified at 47 U.S.C. § 225). Recently, the FCC adopted new regulations to implement the Act. *See Telecommunications Services for Individuals with Hearing and Speech Disabilities, and the Americans with Disabilities Act of 1990,* 69 R.R. 2d 811 (1991).

More generally, the burgeoning of the CPE market over the last decade appears to have significantly benefitted people with disabilities.[365] While TDDs and hearing aid compatible phones have clearly assisted the hearing-impaired, push-button telephones, speaker phones, cordless phones, and visual ringing signalers have greatly improved the accessibility and convenience of telephone service for many other disabled persons.[366] As one commenter points out, the "primary method by which telecommunications services are [now] made available to disabled individuals is through CPE."[367] Consequently, as vigorous competition in the CPE market continues to generate equipment with advanced features and capabilities, disabled Americans will share in the benefits enjoyed by all other CPE users.

Finally, and as discussed above, telecommuting can open new employment opportunities for disabled workers by removing barriers created by distance, commuting, and architecture.[368] Telecommunications can further improve the quality of disabled Americans' lives by facilitating greater interaction among themselves and with others.

Although the United States is moving vigorously to make telecommunications services more accessible to the disabled, we must continue to advance. Because of the limitations imposed by their handicaps, disabled persons will necessarily be more reliant on telecommunications than other Americans. For example, although security/emergency services or health monitoring applications may be important for many people, they may be essential for those confined to wheelchairs.[369] Access to databases and other information services can eliminate physical and geographic barriers to expanded educational opportunities for disabled individuals.[370] Electronic yellow and white pages and bank- and shop-at-home services can dramatically increase the ability of disabled people to satisfy their basic needs.

As telecommunications firms introduce new products and services, they should include in their planning and design processes consideration of the needs of disabled persons, and the ease of operation of these offerings by such persons. The needs of disabled

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[365] *See* Comments of BellSouth Corp., App. B at 34.

[366] *See id.*; Notice, 55 Fed. Reg. at 806, para. 53.

[367] Comments of Ameritech, App. A at 13.

[368] *See supra* at 77.

[369] *See* Comments of NYNEX Corp. at 58; Bowe, *National Survey on Telephone Services and Products: The Views of Disabled and Older Americans* (1990).

[370] *See* Comments of Southwestern Bell Corp. at 25.

Americans should be integrated into the telecommunications system; it is preferable for industry to plan on such integration, rather than be forced into expensive and disruptive retrofitting in response to regulation or statute. NTIA will coordinate with the FCC and the Department of Health and Human Services to explore ways of seeking such industry action.

NTIA discusses ways to make such capabilities more widely available to disabled Americans in subsequent chapters of this report. For example, our discussion of universal service in Chapter 7 is influenced to no small degree by the needs and interests of disabled Americans. In these efforts, the challenge for policymakers is to find mechanisms that can make needed capabilities available to disabled individuals, so as to integrate them more fully into American life in an economical and balanced manner.

While keeping the special needs of the disabled in mind, however, policymakers should recognize that the services that provide most value to the disabled will benefit all users of the telecommunications system. Thus, future advanced services could provide the technological equivalent of light-speed wheelchairs to people who cannot walk, and could enable the deaf to see what they cannot hear. A truly advanced information infrastructure would do more than move the disabled off the unemployment rolls into low-level clerical jobs; it would smooth their path into the ranks of management and professional services and broaden their range of social interaction with the world at large.

VI. CONCLUSION

The foregoing discussion demonstrates the importance of telecommunications to the performance of the U.S. economy and to the health and well-being of its citizens. U.S. businesses increasingly rely on telecommunications capabilities to help them reduce costs, increase productivity, and accommodate the needs and demands of their customers. The availability of adequate telecommunications facilities can enhance the economic, social, and environmental assets of a community and, thus, attract new businesses to that community. Telecommunications can be a powerful tool for improving and expanding delivery of critical education and health care services, thereby reducing the disparities created by geography and distance. Finally, it can help improve the quality of life for many Americans in a variety of ways. Most importantly, telecommunications can, perhaps for the first time in its history, provide a real chance for citizens with disabilities to experience the opportunities that most Americans take for granted.

For all these reasons, the preceding discussion explains why telecommunications issues should be of concern for policymakers at all levels of government. However, the foregoing discussion does not address the vital question of whether there is cause for concern that the domestic telecommunications infrastructure, as it is currently evolving, will not develop the requisite capabilities when they are needed.

These critical issues will be the focus of the remainder of this report. Thus, in the next two chapters, we will attempt to assess the current and future state of the U.S. telecommunications infrastructure. Chapter 4 will provide a detailed sketch of that infrastructure and give some indication of its past evolution, its current capabilities, and its future development. Chapter 5 will examine one way to judge the adequacy of the U.S. telecommunications systems—by comparing its features and capabilities with those of other nations.

The discussions in subsequent chapters will be guided by a fundamental objective. Our intent is to create a regulatory and market environment that will give firms incentives to make efficient and rational investments in the U.S. telecommunications system, so that this portion of the nation's infrastructure will receive its proper share of our scarce resources, and our citizens will receive the substantial benefits that an advanced telecommunications system can deliver. In our view, this objective cannot be achieved by government directives to private companies to increase their investment in telecommunications, nor can it be accomplished by bureaucrats deciding which services or technologies should be the recipients of such investments. Conversely, we will not successfully reach these goals if government policies retard efficient investment, in effect handicapping the development of advanced technologies. We address these issues in Chapter 6, where we examine how existing government policies are influencing the investment decisions of telecommunications firms and what changes in these policies are necessary to promote efficient development of an advanced infrastructure.

Chapter 4 Networks in Transition

I. INTRODUCTION

Public and private telecommunications networks have been evolving dramatically on both a national and global scale over the last several decades. The domestic marketplace includes a wide variety of telecommunications services and equipment alternatives. Vigorous competition in the long-distance telephone market has produced numerous high quality services at low prices.[371] Alternative local access providers, such as Metropolitan Fiber Systems (MFS) and Teleport Communications (Teleport), are increasingly providing services in competition with the LECs.[372] The dramatic growth of cellular telephony, paging, and other mobile services over the last decade offers customers both public and private options for radio services. The rapid increase in private networks has created still other alternatives for both local and long distance communications. An ever-expanding variety of available CPE affords a wide range of network-based and non-net-

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[371] *See* Reply Comments of NTIA in CC Docket No. 90-132 at 6-8 (filed Sept. 18, 1990). Industry estimates indicate that AT&T's market share has dropped from 86 percent in 1985 to 67 percent in 1989. International Trade Administration, U.S. Dep't of Commerce, *1991 U.S. Industrial Outlook 1991*, at 29-3 (Jan. 1991) (*1991 Industrial Outlook*).

[372] Between 1987 and 1990 the number of alternative service provider networks has grown from three networks in three cities to 38 networks in 25 cities. Plans for 1991 project 41 networks operating in 28 cities. Bohlin, *Do LECs Need Magic to Cut Costs?*, Telephony, Apr. 29, 1991, at 32. Estimates place 1990 revenues at $128 million, growing to between $265 million and $580 million by 1995, depending upon pending collocation decisions. Brown, *Alternative Carriers Forge Into Advanced Net Services,* Network World, May 6, 1991, at 9. MFS has systems operating in 11 cities, including Chicago, Boston, and Baltimore. Teleport has systems operating in 20 cities, including New York, Boston, Chicago, Houston, Los Angeles, Dallas, and San Francisco.

Network equipment purchased by public and private non-carrier network providers were estimated to be growing at a two percent rate (in constant dollars), totaling $13.7 billion in 1990. *1991 Industrial Outlook, supra* note 371, at 30-1.

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work-based functions to meet their communications needs.[373] Finally, hundreds of information service providers give both business and residential customers access to over 3,300 databases.[374] Such market activity has been driving U.S. telecommunications development.

Technological advances, coupled with policies promoting competition in service and equipment markets, have permitted the industry to provide increasingly sophisticated services.[375] Such improvements have expanded the capacity and capabilities of the existing telecommunications plant, both wire-based and wireless, thus enabling it to carry more and a greater variety of traffic than was previously possible. Technical progress has also increased the flexibility of service features and reduced the equipment costs, thereby giving customers great independence and control in meeting their individualized needs.

A prime example of rapid technical progress (with potentially major implications for telecommunications infrastructure development) is occurring in the area of radio-based systems. The growth of cellular radio systems has greatly expanded the number of mobile users interconnected with public switched networks. Rapid development of digital cellular transmission standards has offered a way to meet growing demand for mobile service by increasing the capacity of current systems three-fold (and, perhaps, as much as six-fold in later implementations). New radio designs using innovative multiplexing and spread spectrum techniques offer the possibility of even greater capacity gains. The industry has already begun to exploit these and other technical advances to build customized stand-alone radio systems and radio systems interconnected with public networks to meet the needs of both fixed and mobile users.

These technical, regulatory, and market developments present challenges and opportunities for further infrastructure development. One important challenge is the design and operation of networks that permit efficient, integrated transport of voice, data, and video traffic over common facilities. With the emergence of customer demand for advanced features such as service control, remote maintenance, accounting, and billing functions,[376] the industry must develop specialized products and services to meet those needs. Additionally, the presence of numerous service and equipment suppliers has increased pressure to develop technical standards that will allow equipment and systems from different vendors to be used together in a single carrier's network. Such standardization can also facilitate the interoperation of different carriers' networks.

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[373] For example, private network switches (private branch exchanges, or PBXs) routinely perform switching functions that traditionally were provided by LECs through services like Centrex or leased equipment. A 1988 survey of the terminal equipment market showed more than 1,300 types of equipment on the market. *See* Comments of TIA, Attach. A.

[374] Revenues in this industry reached $9 billion in 1990 and continue to grow 20 percent annually. *1991 Industrial Outlook, supra* note 371, at 27-2. *See also* National Telecommunications and Information Administration, U.S. Dep't of Commerce, *NTIA Information Services Report,* NTIA Report 88-235, at vii-viii (Aug. 1988) (*Information Services Report*); Comments of MCI Telecommunications Corp. at 9-15; Comments of CompuServe Inc. at 9; Comments of BT Tymnet, Inc. at 9.

[375] *See, e.g.,* Copeland, *VLSI for Analog/Digital Communications,* IEEE Communications Mag., May 1991, at 25-30; Ahmed and Kline, *Recent Advances in DSP Systems,* IEEE Communications Mag., May 1991, at 32-45.

Another major challenge for the telecommunications industry is to design and implement networks that can accommodate the continuous technical change that characterizes telecommunications. Network planners must provide for investments in new technologies at a rate that efficiently delivers the benefits of technical improvements to consumers. This is, of course, no simple task. Planners have difficulty predicting or anticipating demand for new services under the most favorable conditions. The challenges are more formidable still in a highly competitive, rapidly advancing industry like telecommunications. The fact remains, however, that one of the principal strengths of this nation's open, competitive telecommunications system is the opportunities that it creates for innovators and entrepreneurs to uses of network capabilities not anticipated by network providers or government policymakers. For example, although LECs introduced "touchtone" signalling in 1963 to improve network signalling and customer dialing, uses of touchtone expanded beyond its original purpose,[377] once end users recognized that they could send signalling information through the LEC network to another end user or service provider. Thus, touchtone simplified customer access to competing (non-AT&T) IXCs prior to the introduction of equal access, thereby facilitating interexchange service competition. Similarly, touchtone contributed to the growth of the information services industry which, for certain applications, relies on such signalling for interacting with customers. It is unlikely that the Bell System anticipated or desired either development when it deployed touchtone in 1963.

The prospects for telecommunications providers and infrastructure development are bright. The first hundred years of telephone network development focused on building and improving high-quality point-to-point networks to carry primarily voice traffic. In the future, new technology will permit the rapidly evolving telecommunications infrastructure to convey voice, data, and video traffic to anyone, anywhere through a wide variety of media, including wired, fiber and radio alternatives. A key challenge for policymakers is to develop telecommunications policies that permit private entrepreneurs to develop and exploit these possibilities.

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[376] *See, e.g.*, Bradsher, *Phone Billings Are Improved For Businesses, Not Homes*, N.Y. Times, Mar. 8, 1991, at A1.

[377] *See* Comments of PacTel at 13.

This chapter discusses the recent technical evolution of telecommunications networks. We outline service improvements and innovations associated with these technical developments, and describe current technology deployment strategies of the industry. We also highlight major technical issues confronting the industry and examine, in particular, the appropriate roles and interrelationship of industry and government in addressing such issues.

II. TECHNICAL DIMENSIONS OF TELECOMMUNICATIONS DEVELOPMENT

The record developed from our inquiry demonstrates the steady pace of development and investment in telecommunications transmission, switching, and terminal equipment. Commenters offer numerous statistics showing the impressive achievements of the industry, and cite ambitious future plans for networks carrying voice, data, and video traffic, both here and abroad. The record also provides a glimpse of carriers' plans to evolve their networks toward all-digital, wideband facilities with advanced signalling features.[378]

While telecommunications networks have changed continually since the development of the telegraph and the invention of the telephone, the current pace of technical evolution may be accelerating due to increased competition among service and equipment providers for innovations to be made available in public and private networks. In some cases pro-competitive government policies have had a direct effect on the speed of technology deployment. For example, the requirements of the AT&T Consent Decree and the FCC that LECs provide IXCs with "equal access" to LEC networks accelerated the deployment of electronic switching capabilities (which are necessary to provide such access) throughout those networks. In other cases, competition (resulting in part from government policies) appears to be driving technological improvements. For example, in the interexchange services market, competitive pressures contributed to the early adoption of fiber transmission systems by a number of AT&T's competitors and later propelled movement by almost all IXCs into fiber-based systems.

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[378] *See, e.g., id.* at 24-28, 51; Comments of REA at 8-11; Comments of Ameritech at 19-24, 27, App. A at 15-29.

Current cable television operators are also interested in increasing the capacity, service quality, and utility of their facilities through technical improvements such as the introduction of fiber optic transmission media.[379] In the short run, the development of fiber backbones for cable systems will improve service quality and increase system channel capacity. In the longer term, these fiber backbones may connect two-way wired or wireless services. Such new technologies will join the existing telecommunications network plant in offering basic voice and data telephony services, video and information services, and additional improvements to basic network services.[380]

Because industry participants continually harness technical advances in shaping services to meet market demand, the mix of equipment currently employed in domestic networks reflects diverse and evolving technologies. Prior to the mid-1960s, telecommunications engineers focused chiefly on improving the transmission and switching of analog signals. Indeed, parts of the telecommunications infrastructure, most notably subscriber loops and many central office switches, are still analog. Over the last 25 years, however, the rapid development of digital technology has made the transmission and switching of signals in digital form increasingly attractive.[381] Bell Atlantic, for example, intends for all of its switches to be digital by 1998, as compared to 75 percent today. Bell Atlantic also plans to have almost 70 percent of its access lines served by digital switches in 1995, as opposed to 50 percent today.[382] BellSouth plans to grow from 62 percent digital offices to about 82 percent by 1995.[383] Other LECs are experiencing similar growth.[384] The trend toward digital facilities in both public and private networks will continue.

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[379] *See* Fabrikant, *Time Warner Constructing 2-Way Cable TV System,* N.Y. Times, Mar. 8, 1991, at D5. Cable distribution plant is generally divided into trunk, feeder and drop cables. Fiber optic cable is most commonly used in the trunk portion of distribution plant. National Telecommunications and Information Administration, U.S. Dep't of Commerce, *Video Program Distribution and Cable Television: Current Policy Issues and Recommendations,* NTIA Report 88-233, App. B at 4-11 (June 1988) (*Video Study*).

[380] Tele-Communications Inc., the largest U.S. multiple cable television system operator, will jointly test market, with AT&T and US West, a video-on-demand and enhanced pay-per-view system. Mason, *Rivals Team in CATV Deal,* Telephony, May 6, 1991, at 3.

[381] The digital "revolution" in communications actually reflects two facts. First, for many purposes, digital transmission has better performance characteristics than analog alternatives. A major advantage of transmitting signals digitally is signal durability and the ability to regenerate "noise-free" signals as required over long transmission distances. Digital transmission also has a high immunity to noise and interference, and can be designed to convey numerous signals at lower cost than analog transmission of a comparable volume of signals.

Second, widespread use of computers has stimulated the demand for transmission of data in digital form over networks that historically carried predominantly analog voice messages—such that the mix of traffic has been changing over the last several decades. At the same time, the number of data terminals has been growing at a rate of 20 percent annually compared to a voice terminal annual growth rate of four percent. Eigen, *Narrowband and Broadband ISDN CPE Directions,* IEEE Communications Mag., Apr. 1990, at 39.

[382] Bell Atlantic, *Investor's Reference Guide* 18 (Apr. 1991).

A. NETWORK CONSIDERATIONS

As noted in Chapter 2, the U.S. telecommunications infrastructure is comprised of a multitude of public and private networks. A network, most simply defined, is a system that interconnects users.[385] All networks, whether public or private, large or small, draw upon a common set of technological possibilities for terminal equipment, transmission media, switching facilities, and signalling systems to meet user requirements.[386] The "simplest" networks may require no switching, instead using direct connections between each pair of user terminals. Generally, however, networks use switching technologies to reduce the number of transmission links required. This reflects cost-performance tradeoffs between switching equipment and transmission links.[387] Even more sophisticated systems may use dedicated signalling networks working in conjunction with message networks, as well as subsystems devoted to network maintenance and traffic control. Today's private and public networks use numerous combinations of the technologies described below.

B. TRANSMISSION MEDIA

Prior to the deployment of cost-effective fiber optic (or lightwave) technology during the last decade, transmission equipment for U.S. telecommunications networks was composed of copper-based media and, on a more limited basis, point-to-point microwave radio. Copper-based media have been refined extensively to carry digital traffic, and twisted copper pairs still are very dependable for the conveyance of voice and data traffic, especially in situations of low traffic density. Moreover, researchers continue to expand the capabilities of copper plant. For example, recent reports on research at Bellcore and other laboratories indicate that there has been substantial progress on the transmission of compressed VCR-quality video over copper wires.[388]

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[383] We discuss specific deployment statistics later in this chapter. *See generally Deloitte and Touche Study, supra* note 27, Vol. II, at IV-91 to IV-92.

[384] For example, statistics from 1984 through 1988, gathered from LECs with REA financing, showed the number of digital switches growing from about 1,100 to about 2,100 switches. Digital remote switches, during that same period grew from almost 1,250 to almost 2,800 switches. *See* Comments of REA at 9.

[385] Networks take a variety of forms. For example, a fully-connected network would use direct connections between each pair of user terminals. In contrast, a star network has a switch in the star's center, and requires every connection to be made through the switch. A ring network would connect all users together in a ring. Under this arrangement, calls to nonadjacent parties would be directed past non-called parties. A tree network, as used in traditional cable television services, connects a cable "head-end" to a subscriber through successively smaller branches. Combinations of these configurations are also possible.

[386] Of course, size, capacity, and cost requirements will often dictate the use of specific technologies for particular applications.

[387] Historically, it has been economical to use switching capabilities to reduce transmission requirements. Experts differ as to how these tradeoffs will develop in the future.

Microwave radio[389] has been used in both long-haul and shorter-haul applications and can carry large amounts of analog and digital traffic. Commercial terrestrial fixed microwave radio now operates at radio frequencies between 1.7 and 23 gigaHertz (GHz). Such systems can carry very large amounts of traffic. AT&T, for example, operates a digital radio system at 11 GHz that carries more than 13,400 voice channels per microwave link. However, there are certain limitations in working with microwave transmission. For example, microwave radio signals propagate in a "line-of-sight" manner and are susceptible to fading from rain and other environmental conditions. Moreover, the higher operational frequencies require a shorter distance between repeaters. As a result, digital radio systems operating at 11 GHz might typically require repeaters or signal regeneration at distances of 20 miles or less, depending upon rainfall conditions.

Satellite radio services can also carry large amounts of traffic. Satellite radio frequencies at 4 GHz and 6 GHz and at 12 GHz and 14 GHz accommodate "C" and "Ku" band services. A third band, the "Ka" band, has been authorized at 20 GHz and 30 GHz. A typical transponder bandwidth is 36 megaHertz (MHz), accommodating as many as 6 television channels. Since satellite services are especially good for point-to-multipoint wideband applications, they are used, for example, to deliver television programming to a large number of cable television system "headends" around the country. One characteristic feature of satellite transmission is the half second delay experienced when two parties communicate. This delay, which occurs because the radio waves must travel some 22,000 miles from earth to a satellite stationed above the equator and back, makes satellite services less desirable to employ in certain high speed interactive, real-time communications when terrestrial wideband alternatives are available.[390] Nevertheless, satellites have played a major role in providing two-way services, such as ordinary voice services, over long distances. For example, satellite capacity provided through the Intelsat system has extended substantially the capabilities and capacity of international networks so that two-way communications is now possible between virtually any two countries in the world.

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[388] *See, e.g.*, Wong, *MCPIC: A Video Coding Algorithm for Transmission and Storage Applications*, IEEE Communications Mag., Nov. 1990, at 24-32. *See also* Chow, Tu, and Cioffi, *Performance Evaluation of a Multichannel Transceiver System for Asymmetric Digital Subscriber Lines* (Dec. 12, 1990) (submission no. 90-211 to T1E1.4 Technical Standards Subcommittee).

[389] Included in this term are terrestrial and satellite radio. Terrestrial radio systems communicate between land-based transceivers, with terrestrial repeater stations for longer distance communications. Satellite radio systems are long-haul systems relying upon earth stations and orbiting satellite repeaters. Land mobile radio, which also operates in the microwave portion of the radio spectrum, will be discussed in a later section.

Fiber optic transmission is replacing copper and radio transmission systems for routes with sufficient traffic density, because of its declining costs and extremely high capacity.[391] Fiber systems deployed commercially at 1.2 gigabits per second (Gbps) and 1.76 Gbps can carry 18,816 and 24,192 voice channels per fiber pair respectively. The addition of wavelength division multiplexing will allow these capacities to increase even more.[392] Compared to copper or radio-based alternatives, fiber optic transmission systems have greater immunity to interference, exhibit low signal loss, and can carry a much greater amount of traffic accurately at greater distances. These systems also have lower maintenance and servicing costs than comparable terrestrial alternatives.[393] As a result, fiber optic transmission facilities are increasingly used in public and private networks. This is particularly true in the competitive long distance market, but it is increasingly the case in local exchange and cable networks, as well. Corning estimates that 75 percent of interexchange facilities and 51 percent of interoffice facilities have been fibered. The major IXCs have installed over 2.1 million fiber miles. Local exchange carriers have installed over 3.1 million fiber miles for use in interoffice applications and,

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[390] A. M. Noll, *Introduction to Telephones and Telephone Systems* 46-53 (1986) (*Noll*).

[391] Fiber optic transmission systems usually include light sources, optical fiber strands, and light detectors. A light source, consisting of a light-emitting diode (LED) or laser, is switched on and off very quickly corresponding to a code representing the message communication. This light is directed through low loss glass fibers (several optical grade designs are available) and received by a detector, usually a light sensitive solid-state diode. These diodes convert the optical signals to electrical signals so that the message can be reconstructed. The transmission distance of a lightwave system can be increased with the use of regenerative repeaters.

[392] Industry Analysis Division, Common Carrier Bureau, Federal Communications Commission, *Fiber Deployment Update* 38 (Mar. 1991) (*Fiber Deployment Update*). A common single fiber pair operating at 565 megabits per second (Mbps) can carry more than 8000 voice channels. Commercial optical transmission systems, with 96 fibers, have a maximum capacity of more than 384,000 voice channels. Fiber repeater stations spaced at 25 miles or more permit large equipment cost savings for long transmission routes. *See* Northern Telecom, *Product Handbook: Technology the World Calls On* 386 (8th ed. 1989). Lower capacity systems carry more than 2000 voice channels per fiber pair over unrepeatered spans of 18 miles. *See id.* at 399.

[393] *See, e.g.*, Personick, *Fiber Optics: Technology and Applications* (1985).

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to a more limited degree, loop plant.[394] As shown in Table 4.1, by 1994 the BOCs plan to double the amount of fiber installed in 1989, thereby bringing the total deployment to almost seven percent of all in-place transmission plant, measured in terms of sheath miles.[395] GTE projects that 11.2 percent of its sheath miles will be fiber by 1994.[396] Growth rates could well increase as the fiber technology itself continues to develop.[397]

Although the advantages of fiber optics for some applications are startling, this technology does pose some design tradeoffs. These systems require extensive use of relatively high cost optoelectronics, used for converting signals between the electronic and the optical domains when circuits are switched electronically, or at network termination points for connection to electronic customer equipment. For applications requiring very large numbers of voice channels or very high bandwidths, the advantages of fiber-optic transmission systems predominate. In these cases, the cost of optoelectronic devices can be shared over a large number of channels, making the per channel cost lower than for other media. Optoelectronic costs have been falling significantly in recent years and, if this trend continues, the attractiveness of fiber optic transmission systems for lower capacity applications will grow. Another practical disadvantage is that fiber, historically, has been significantly harder to splice than copper media. However, as the industry has moved to develop field splicing gear, the exacting task of splicing fiber has become less difficult.[398] Both the current cost of optoelectronics and such operations issues as splicing fiber in the field help explain, in part, the lack of fiber deployment to the home.[399]

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[394] Corning, *The Extent of Fiber Deployment in the United States* 2 (Apr. 9, 1991) (presentation to NTIA) (Corning Presentation). The BOCs have deployed aggregate amounts totaling 2.7 million fiber miles. However, only 1 million fiber miles were used in loop plant. Other LECs including Contel, GTE and United reported over 400,000 fiber miles deployed. Fifteen alternative service providers, marketing fiber-based services in urban areas, reported about 55,000 fiber miles. *Fiber Deployment Update*, *supra* note 392, at 20, 32.

Cable television system operators are also finding fiber useful in their operations. For example, Tele-Communications, Inc., whose systems have more than 8.5 million subscribers, plans to replace copper cable in its systems with optical fiber. *Cable Firm to Upgrade With Optical Fiber*, Wash. Post, Apr. 12, 1991, at C2. The cable industry is estimated to have installed 4,000 route miles in 1990 alone, totaling about 90,000 fiber miles. This estimate is nearly double the 1989 amount and seven times the 1988 amount. Myers, *High Fiber* 3 (AT&T Bell Laboratories Special Report on Network Cable Systems 1991)

[395] Sheath miles of fiber are calculated as the number of route miles of fiber times the number of fiber cables deployed along each route. Fiber miles can be estimated by multiplying the number of sheath miles times the number of fibers in each cable. Although sheath miles do not measure the transmission capacity of the fiber being deployed, they are a measure of relative activity in deploying fiber.

[396] Comments of GTE Service Corp., App. D.

[397] Research on fiber technology is proceeding on a number of fronts. For example, research activities include developing ultra-low loss fiber that increases the distance a light signal can travel through a fiber medium without regeneration, increasing the speed of signalling devices, and multiplexing and amplifying optical signals.

MCI has been testing 2.4 Gbps electronics in its laboratory and expects to increase the capacity of a fiber pair to 3.6 Gbps. *See* Comments of MCI Telecommunications Corp. at 26.

AT&T Bell Laboratories recently announced development of a laser diode that can produce 350 billion light pulses a second. If each light pulse were to generate one bit of information, the information rate of this diode would be 350 Gbps. This signalling speed is three times faster than the previous record and 150 times faster than present commercial devices. Commercial development of the new diode could increase the capacity of lightwave systems 150 times the capacity of commercial systems. *See* IEEE, *The Institute* 6 (Mar. 1991).

	1989				1994			
COMPANY	TOTAL COPPER	%	TOTAL FIBER	%	TOTAL COPPER	%	TOTAL FIBER	%
Ameritech	318,880	96.7	10,882	3.3	352,339	93.9	22,889	6.1
Bell Atlantic	294,188	96.1	11,939	3.9	307,699	89.6	35,715	10.4
BellSouth	564,162	96.6	19,857	3.4	589,814	92.5	47,823	7.5
NYNEX	262,026	96.6	9,222	3.4	288,651	93.1	21,393	6.9
Pacific Bell/ Nevada Bell	191,767	97.9	4,113	2.1	208,391	94.8	11,431	5.2
Southwestern Bell	375,168	97.7	8,832	2.3	372,876	96.6	13,124	3.4
US WEST	419,268	96.9	13,413	3.1	435,793	92.1	37,381	7.9
Total	2,425,459	96.9	78,258	3.1	2,555,892	93.1	189,427	6.9

SOURCE: BOC data filed in Rate of Return Represcription proceeding, CC Docket 89-624 (Feb. 1990).

Table 4.1: Fiber *vs.* Copper Deployment (BOC Sheath Miles)

In the aggregate, U.S. public and private networks use a mix of transmission media appropriate for different situations. Fiber is the transmission medium of choice in mid-to-high density traffic situations. Radio is used where the need for mobility (*e.g.*, cellular service) or right-of-way constraints (*e.g.*, fixed microwave service) make it a preferred alternative. Copper is still a very attractive alternative for low density traffic situations. As the relative costs of these media change with innovation, preferences may also change. In the near term, however, it appears clear that fiber and radio will be used increasingly in fixed and mobile applications, respectively.

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[398] *See* GTE California Inc., *1990 Report on Cerritos* 14 (Apr. 1, 1991).

[399] Other operational issues include how to supply electrical power to terminal equipment connected to fiber loops. *See infra* notes 491-493 and accompanying text.

C. TRANSMISSION SYSTEM IMPROVEMENTS

As noted above, transmission systems, regardless of the media used, have become increasingly digital in nature because of digital transmission's superior performance characteristics. In addition to these benefits, fully digital networks would reduce the need for modem equipment for data transmission and would allow voice and data traffic to be carried in an integrated fashion. With these advantages and the declining cost of digital electronics, digital transmission systems have become commonplace in private and public networks.[400] Public network providers and equipment manufacturers have deployed mature multichannel private line digital or T1 services, and they have been developing implementations of all-digital Integrated Services Digital Network (ISDN) for over a decade.[401]

Coincident with the deployment of digital facilities has been the continued evolution of innovative encoding, processing, and transmission messaging techniques, each designed to improve the movement of voice, data, and video traffic over the ever-changing mix of media used in public and private networks. Voice compression technology already permits reduced digital transmission capacity requirements for high-quality voice messages; technical research shows substantial progress toward further reductions.[402] Video compression technology now under development has even more ambitious goals, and could allow broadband signals, including video traffic, to be carried on facilities not previously able to accommodate such traffic.[403]

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[400] Pacific Bell, for example, plans to have 100 percent digital inter-offices facilities by the end of 1991. *See* Comments of PacTel at 24. In 1990, AT&T almost doubled its DS1 digital capacity to two billion channel miles, up from 1.2 billion channel miles in 1989. Communications Daily, May 15, 1991, at 3.

[401] "Basic rate" ISDN services allow a loop to carry two channels of voice or data, along with a third channel carrying signalling and data. Higher capacity services, known as "primary rate" services, give users access to 23 channels for voice or data in addition to a signalling channel. Standards for even higher capacity digital services (broadband ISDN or B-ISDN) are under discussion in international standards fora. Some believe that narrowband ISDN development will be overtaken by broadband developments.

[402] While international public network technical standards already exist for digital voice telephony at 64 kilobits per second (Kbps) and 32 Kbps, current research efforts center on using lower bit rates for encoding voice transmissions. The new standard for digital cellular service, for example, has a digital voice rate of 8 Kbps. Parker, *Personal Communications Services: Poised for Growth,* Telecommunications, Apr. 1991, at 63.

[403] For example, one objective of current research in video compression is to reduce a broadcast television (continued...)

Other improvements in transmission continue. Most switched voice networks still use circuit switching and conventional multiplexing for digital and analog transmission.[404] However, the successful development of digital packet transmission techniques[405] for data applications has been followed by efforts to devise fast-packet transmission techniques for voice, broadband data, and video applications.[406] The technical literature is replete with discussions of the merits of transmission messaging techniques such as frame-relay[407] for common digital transmission speeds, and cell-relay or asynchronous transfer mode[408] for speeds above 1.5 Mbps.[409] Clearly, then, telecommunications transmission techniques are being refashioned constantly to deliver messages faster and more efficiently.[410]

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403 (...continued from preceeding page)
signal more than 60-fold, allowing such signals to be conveyed digitally over existing public network plant.

Advanced television signals, such as high definition television (HDTV) transmissions, require transmission of much more information than current broadcast television signals, and will necessitate much greater gains in compression if such signals are to be carried over existing plant. A recent estimate suggests that an uncompressed HDTV signal with forward error correction would require about 1.3 Gbps. Rast, *FCC Tutorial: Compression Techniques for Digital Television* (Mar. 7, 1991). Video compression systems currently under development are being designed to allow a single HDTV signal to be carried over a 6 MHz television channel.

[404] In circuit switching, a dedicated transmission path, or circuit, is established and held by users for the entire duration of the call.

[405] Packet techniques currently are used for data communication needs that are primarily bursty in nature, especially applications such as interactive communications between computer hosts and remote users. Messages are divided into specific length blocks, or packets, that use channel capacity only during active communications. During a pause in communications, this channel capacity can be used to carry packets from other users. This technique allows channel capacity to be used more efficiently than typically is the case in circuit-switched applications.

[406] Fast-packet switching techniques increase the speed of conventional packet systems by taking advantage of low error rates of improved transmission media and reducing signalling overhead information required for conventional packet systems. Fast-packet technology is currently being designed to support wideband data services, such as Bellcore's switched multimegabit data service (SMDS), up to 45 megabits per second (Mbps). Fast-packet technology is expected eventually to operate over synchronous optical networks at rates over 600 Mbps.

[407] Frame relay is a "connection-oriented" fast packet switching technology used for signalling and data transmission, typically in bursty traffic applications. Frame relay relies on dynamic bandwidth allocation to provide efficient transmission services.

[408] The asynchronous transfer mode (ATM) uses fixed-sized packets or cells that are 53 bytes long. SMDS uses a cell-relay protocol similar to the ATM developments for broadband ISDN. Schriftgiesser, *Riding the Data Boom,* Telephony, Mar. 18, 1991, at 122.

[409] *See, e.g.*, Fleming, *What Users Can Expect From New Virtual Wideband Services,* Telecommunications, Oct. 1990, at 29-36.

[410] Several BOCs are conducting frame relay trials. *See* Emigh, *Interest Mounting in Frame Relay,* Telephony, Mar. 18, 1991, at 34. Other network operators are showing interest as well. US Sprint and WilTel, long distance carriers, and BT Tymnet and CompuServe, information service providers, have announced frame-
(continued...)

As noted above, some transmission technologies and media may be more appropriate for particular applications than others. Consider, for example, the differences in traffic volume carried over various portions of a public network, and the technologies used in these applications. The contrast is most dramatic when considering interoffice traffic (*i.e.*, transmissions between switches) and "loop" traffic (*i.e.*, transmissions between a customer and the nearest network switch). Interoffice transmission is typically a very high-density application that can benefit from the use of high capacity technologies, like fiber optics. Loop transmissions are not usually high density applications, but they may involve a mix of densities travelling over relatively short distances. Large business users typically generate higher traffic volumes than small business customers which, in turn, generally produce larger amounts of traffic than residential subscribers. Loop facilities, which represent a substantial portion of LEC investment, employ various transmission technologies to meet the large variety of customer traffic needs.[411] These technologies also must be sufficiently adaptable to meet changing future needs.

Development of loop plant presents special challenges for service providers because it must evolve to meet the needs of an increasingly diverse mix of customers that demand a wide variety of services. In response to customer needs and carrier efforts to improve service efficiency, progressive changes have occurred since the deployment of traditional copper-based loop plant. In response to subscriber growth during the 1970s, LECs introduced digital "pair gain" systems into public networks, using carrier and concentration technologies to increase the number of customers that could be served by the embedded copper plant. These systems collect traffic from individual customer lines at remote sites and combine, or concentrate, them onto multichannel feeder plant for transmission to the local switch.[412] The aggregation of traffic over such plant has increased the attractiveness of using fiber optic and other multichannel media in these loop applications.

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410 (...continued from preceeding page)
relay network services. *See* Lindstrom, *Wiltel Frame Relay Up and Running*, Telephony, Apr. 1, 1991, at 9; Schultz, *Public Frame-Relay Race*, Communications Week, Feb. 4, 1991, at 27..

[411] Recent estimates suggest that loop plant (consisting of feeder, distribution, and drop facilities) totals 92 percent of network facilities. *See* Corning Presentation, *supra* note 394, at 2. Through the 1980s, loop plant grew at an average rate of almost three percent annually. *Telephone Trends*, *supra* note 30, at 22, Table 16.

[412] Digital loop carriers, for example, allow 96 residential subscribers to be served by three to five digital transmission lines. Business customers, requiring multiple voice grade lines or data channels, use dedicated facilities or share loop carrier systems.

Another aspect of loop technology development focuses on allowing one or more data streams to be carried along with traditional voice messages on existing loop facilities, thus expanding their capacity. Basic rate ISDN, with one signalling channel and two channels that can be used for voice or data, is an example of this so-called "derived channel" technology, which requires unloaded loop facilities and advanced electronics in switches and on the customer premises.[413] Tables 4.2 and 4.3 show BOC plans to equip more than 24 percent of their switches (and about 50 percent of their access lines) with ISDN by 1994, up from less than two percent of switches in 1989 (and less than one percent of lines). GTE projects ISDN availability to 2.4 percent of its lines by 1994.[414]

LECs recently have begun a series of fiber loop trials that apply traffic aggregation techniques over fiber media for service to residential customers.[415] These experiments include both fiber-to-the-home (FTTH) configurations, which require running dedicated fibers and optoelectronics to homes, and fiber-to-the-curb (FTTC) configurations, which employ fiber between switching centers and curbside pedestals, and copper links between the pedestals and individual customer locations.[416] Table 4.4 lists such trials, more than 40 of which are domestic.

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[413] Until recently BOC deployment of ISDN has been characterized as slow. *See* Bushaus, *Users Eye PRI ISDN*, Communications Week, Mar. 4, 1991, at 28; Wallace, *RBHC ISDN Delays Hobble User Plans*, Network World, Feb. 11, 1991, at 15. However, Bellcore recently announced the BOCs' revised ISDN deployment plans. According to Bellcore, Ameritech plans to make 83 percent of its 14.6 million access lines ISDN-capable by 1994, up from 2.2 lines in 1991. Bell Atlantic plans to increase ISDN access from 6.9 million lines in 1991 to 17.1 million lines (90 percent of its access lines) by 1994. BellSouth plans to provide ISDN access to 10.5 million lines (52 percent of its access lines) by 1994, up from 3.1 million lines in 1991. Nynex plans to make 4.4 million access lines (27 percent of its lines) ISDN capable by 1993, up from a 1991 total of 2.1 million lines. Pacific Bell plans to provide ISDN access to at least 6 million access lines (40 percent of its lines) by 1994, up from a planned deployment of 3.7 million lines. Southwestern Bell expects to increase ISDN access from 1.1 million lines to 4.4 million lines (32 percent of its access lines) by 1994. US West plans to increase ISDN access from 3 million lines to 7.3 million lines (51 percent of its access lines). Wallace, *RBHCs Revise Schemes for ISDN Rollout*, Network World, Apr. 29, 1991, at 1.

[414] Comments of GTE Service Corp., App. D.

[415] Because large business customers can aggregate traffic over private networks prior to connecting to public networks via loops, they may be able to use fiber loop capacity more efficiently than individual residential customers with lower traffic volumes.

[416] Nynex, for example, plans to conduct a FTTC trial in 1991 involving 400 residences in Poughkeepsie, New York. The fiber will carry telephone services and can be fully upgraded to broadband service including digital video. Karpinski, *Nynex Prepares FTTC Trial*, Telephony, May 6, 1991, at 3. Indiana Bell has planned a FTTC trial in Columbus, Indiana in 1991. Cable television programming and telephone service will be sent over fiber to network pedestals. Telephone service from the pedestals to homes will be delivered by copper wire, while digital cable television signals will travel over coaxial cable. *See* Telecommunications Reports, May 6, 1991, at 8.

COMPANY	1989	1990	1991	1992	1993	1994
Ameritech	5.4					51.7(a)
Bell Atlantic	2.0					52.1(b)
BellSouth	1.1					13.8(b)
NYNEX	0.9					4.1
Pacific Bell/Nevada Bell	0.5	5.6	10.4			14.4
Southwestern Bell	0.8		3.8	9.8		12.5(a)
US WEST	2.6					13.1(a)
Total	1.9					23.1

(a) 1994 BOC technology deployment projection, based on Wallace is higher than that submitted in the Rate of Return Represcription proceeding, CC Docket No. 89-624 (Feb. 1990).

(b) 1994 BOC technology deployment projection, based on Wallace is lower than that submitted in the Rate of Return Represcription proceeding, CC Docket No. 89-624 (Feb. 1990).

SOURCES: BOC data filed in Rate of Return Represcription proceeding CC Docket No. 89-624 (Feb. 1990); Wallace, *RBHCs Revise Schemes for ISDN Rollout*, Network World, Apr. 29, 1991, at 1.

Table 4.2: Integrated Services Digital Network (ISDN)
(% BOC Central Offices Equipped for ISDN)

Southern Bell conducted one of the earliest FTTH trials in Heathrow, Florida, beginning in mid-1988.[417] This trial involved operating dedicated fiber transmission links to more than 250 subscribers to support ISDN and cable television services, including 54 cable television channels and an "impulse" pay-per-view video service. Each subscriber received four cable television channels and ISDN service simultaneously over a digital fiber link, plus two-line telephone service with custom calling features over a second fiber link. These three services were fed into an Optical Network Interface (ONI) or optoelectronic conversion equipment, mounted in the subscriber's garage, for distribution to his or her terminal equipment. This trial has allowed Southern Bell and equipment vendors to gain operational experience with the delivery of integrated services over fiber to the home, testing ONI and network architecture designs, experimenting with digital video switching equipment.

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[417] Balmes, *The technology behind Heathrow*, Telesis 1989, Vol. 2, at 31-41.

COMPANY	1989	1990	1991	1992	1993	1994
Ameritech	0.2					83.6
Bell Atlantic	0.02					90.0
BellSouth	0.03					52.0
NYNEX	0.05		5.0		27.0	
Pacific Bell/Nevada Bell	0.001		3.7			40.0[a]
Southwestern Bell	0.1					32.0
US WEST	0.3					51.0
Total	0.1					49.8

(a) BOC projection for technology deployment, in 1994, based on Wallace is between 40% and 50%.

SOURCES: RBOC data filed in Rate of Return Represcription proceeding, CC Docket No. 89-624 (Feb. 1990); Wallace, *RBHCs Revise Schemes for ISDN Rollout*, Network World, April 29, 1991, at 1.

Table 4.3: Integrated Services Digital Network (ISDN)
(% BOC Lines with Access to ISDN)

GTE's ongoing FTTH trial in Cerritos, California[418] is using a fiber "test bed" in excess of 2,300 fiber miles that passes more than 800 homes.[419] GTE is conducting four different tests in Cerritos. The largest test involves delivering telephone service digitally over fiber to 180 homes.[420] A second test uses equipment from a different vendor to deliver telephone service digitally over fiber to seven homes. A third test integrates delivery of video and telephony service to four homes. This test delivers two analog video channels over a fiber, as well as two digital voice channels and one simultaneous data channel. The fourth test, currently involving two homes, feeds 20 simultaneous cable

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[418] In 1989, the FCC approved a "good cause waiver" allowing GTE to go forward with the development of a coaxial and fiber test bed to operate cable television and other services. *See General Tel. Co. of California*, 4 FCC Rcd 5693 (1989), *petition for rev. granted and remanded sub nom. National Cable Television Ass'n, Inc. v. FCC*, 914 F.2d 285 (D.C. Cir. 1990).

[419] GTE also built a 78 video channel coaxial network, with 39 channels leased by Apollo Cablevision to provide basic and premium cable television services. More than 170 miles of plant pass 15,100 residences, providing service to almost 7,360 homes.

[420] *See* GTE California Inc., *1990 Report on Cerritos* (Apr. 1, 1991).

TRIAL OPERATOR	TRIAL LOCATION	SERVICES PROVIDED	HOMES PLANNED	TRIAL STATUS
ALLTEL	Charlotte, NC	P	52	Building
Ameritech (Indiana Bell)	Indianapolis, IN	P V D	100	Planning
Ameritech (Ohio Bell)	Cleveland, OH	V		Complete
Ameritech (Ohio Bell)	Columbus, OH	P	72	Building
Ameritech	TBD			Planning
Bell Atlantic (C&P Tele.)	Loudoun County, VA (I)	P V	77	Building
Bell Atlantic (C&P Tele.)	Loudoun County, VA (II)	P	49	Building
Bell Atlantic (C&P Tele.)	Perryopolis, PA	P V	100	Complete
Bell Atlantic (NJ Bell)	South Brunswick, NJ	P D	108	Complete
BellSouth	North Carolina	P	117	
BellSouth (S. Central Bell)	Louisville, KY	P	64	Building
BellSouth (S. Central Bell)	Memphis, TN	P	99	Complete
BellSouth (Southern Bell)	Charleston, SC	P	100	Complete
BellSouth (Southern Bell)	Charlotte, NC	P	90	Planning
BellSouth (Southern Bell)	Columbia, SC	P	285	Planning
BellSouth (Southern Bell)	Lake Norman, NC	P D	42	Complete
BellSouth (Southern Bell)	Marietta, GA	P	163	Building
BellSouth (Southern Bell)	Miami, FL	P D	200	Complete
BellSouth (Southern Bell)	Norcross, GA	P	135	Complete
BellSouth (Southern Bell)	Orlando, FL	P	117	Building
BellSouth (Southern Bell)	Orlando, FL	P V D	256	Complete
BellSouth (Southern Bell)	Orlando, FL	V	251	Complete
BellSouth (Southern Bell)	Savannah, GA	P	216	Complete
BellSouth (Southern Bell)	Sawgrass, GA	P		Planning

P - POTS V - Video D - Data

Table 4.4: Fiber to the Subscriber (FTTS), by Operator
(Table continues on next page)

TRIAL OPERATOR	TRIAL LOCATION	SERVICES PROVIDED	HOMES PLANNED	TRIAL STATUS
British Telecom	Bishops-Stortford, UK (BIDS)	P	240	Planning
British Telecom	Bishops-Stortford, UK (TPON)	P V	240	Planning
Contel	Hisperia, CA (San Bernardino)	P V D	3300	Planning
Contel	Ridgecrest, CA	P	192	Building
Contel	Sidney, NY	P	600	Planning
Contel	Virginia Research Center			Planning
Contel	Wyoming, MN	P	270	Building
Deutsche Bundespost (DETECON)	Bremen			
Deutsche Bundespost (DETECON)	Cologne, West Germany	P V	192	Planning
Deutsche Bundespost (DETECON)	Frankfurt/Main			
Deutsche Bundespost (DETECON)	Leipzig, East Germany	P	10000	Planning
Deutsche Bundespost (DETECON)	Lippetal, West Germany	V	4500	Building
Deutsche Bundespost (DETECON)	Nuremberg		200	Planning
Deutsche Bundespost (DETECON)	West Berlin, Germany	P V D		Unknown
GTE - General Telephone	Cerritos, CA (I)	P V	100	Building
GTE - General Telephone	Cerritos, CA (II)	P D	100	Complete
GTE - General Telephone	Cerritos, CA (III)	V	5	Building
GTE - General Telephone	Cerritos, CA (IV)	P	143	Complete

P - POTS V - Video D - Data

Table 4.4: Fiber to the Subscriber (FTTS), by Operator, Continued
(Table continues on next page)

TRIAL OPERATOR	TRIAL LOCATION	SERVICES PROVIDED	HOMES PLANNED	TRIAL STATUS
Jutland Telephone/ Arcodan	Struer, Denmark	V		Planning
Nynex	Lynnfield, MA	P	100	Complete
Nynex	NyNex Science & Tech Labs	P V	0	Complete
PTT Telecom (Netherlands)	Amsterdam, Netherlands	P V	200	Planning
Pacific Bell	Menlo Park, CA	P D	142	Planning
Quebec Tel	Rimouski, Quebec	P V D	25	Complete
Southwestern Bell	Fort Worth, TX	P V	80	Complete
Southwestern Bell	Leawood, KS	P V	132	Complete
Southwestern Bell	Olathe, KS	P	260	Complete
Telefonica	Madrid, Spain	P		Planning
Telefonica	Madrid, Spain	P	100	Planning
US West	Denver, CO	P	250	Building
US West	Mendota Heights, MN	P	78	Complete
US West	Scottsdale, AZ	P	70	Planning
US West	Scottsdale, AZ	P	86	Complete
US West	South Dakota		1600	Planning

P - POTS V - Video D - Data

SOURCE: Corning, "The Extent of Fiber Deployment in the United States," January 1991, at 3.

Table 4.4: Fiber to the Subscriber (FTTS), by Operator (Concluded)

television channels digitally at a rate exceeding 2 Gbps along with 1.544 Mbps for multiple voice and data channels. This test also provides video on demand service and two-way digital video transmission, permitting videophone service between subscribers. In its most recent annual report on the Cerritos trial, GTE cited progress and experience gained in dealing with fiber splicing, powering, and broadband switching issues.

Although these FTTH trials demonstrate the potential of fiber deployment throughout the network, network planners point out that FTTC deployment may be a better initial strategy. FTTC applications permit the sharing of common fiber and optoelectronics costs among large groups of customers within a few hundred feet of each pedestal location. These designs take advantage of the fact that the capacity of copper loops varies directly with gauge and inversely with distance, so that the bandwidth that can be delivered over the short distance from a pedestal to the home (while not as large as with a fiber loop) is substantially greater than available today.[421] Moreover, FTTC loops may be upgraded later by substituting fiber for the remaining copper loop plant.[422] In this way, a relatively smooth migration path could exist for the deployment of fiber to end users, as when customer traffic can no longer be accommodated economically by copper loop plant. Indeed, an important design consideration for new loop and replacement plant construction is to plan for future traffic needs in a manner that minimizes costly "retrofitting."[423]

Several LECs have announced aggressive FTTC development plans. For example, while NYNEX projects that FTTC designs will reach cost parity with copper alternatives within two to four years, Southern Bell believes that FTTC is economical for its purposes today.[424] Ameritech believes that FTTC will be cost-competitive with copper for new construction in digital carrier applications in 1992.[425] One reason for the differences among these assessments of fiber viability may be the differing market conditions facing these carriers. Southern Bell, for example, is reported to advocate heavy fiber deployment because steady telephone service growth in its service area can take advantage of the economics of density provided by fiber transmission system.[426] Moreover, climatic conditions in Southern Bell's service area, which can cause corrosion of metallic plant, may also argue for more rapid deployment of fiber in loops. Table 4.5 shows BOC plans to deploy fiber over more than 10 percent of the working channels in their local loops.

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[421] The actual capacity of conventional copper twisted pair plant will vary with distance. A 24-gauge twisted pair copper wire can carry 1.5 Mbps of traffic to about 6 kilofeet or 2.4 Kbps to about 10 miles. For shorter distances, with appropriate modifications, such plant can provide even greater capacity. Mier, *Weighing Factors in the Twisted-pair/Fiber Choice*, Network World, Apr. 29, 1991, at 1.

[422] *See, e.g.*, Southern Bell, *Cost Trends for Fiber in the Loop Deployment* 3.

[423] Selander cautions that today's best topologies (based on low installed first costs) are not necessarily the best options for the future, particularly for switched broadband upgrades and for enhanced network services expected in the future. Selander, *Stalled on the Way to the Home* 8 (June 1990) (Working Paper prepared for TIA) (*Selander*).

[424] *Telephony Transmission Special*, Nov. 1990, at 9-10.

[425] Wilson and Karpinski, *The 'Conservative' RHC Breaks the Mold*, Telephony, Apr. 22, 1991, at 36.

[426] For a discussion of how telephone companies' inability to provide video and other new services may slow the pace of fiber loop deployment, see Selander, *Stalled on the Way to the Home* 8 (June 1990) (Working Paper prepared for TIA).

COMPANY	1989		1994	
	COPPER (%)	FIBER (%)	COPPER (%)	FIBER (%)
Ameritech	94.8	5.2	92.0	8.0
Bell Atlantic	96.9	3.1	86.6	13.4
BellSouth	95.79	4.21	85.7	14.3
NYNEX	98.2	1.8	95.0	5.0
Pacific Bell/Nevada Bell	99.52	0.5	91.21	8.8
Southwestern Bell	98.3	1.7	83.7	16.3
US WEST	98.8	1.2	95.4	4.6
Total	97.3	2.7	89.96	10.1

* Fiber deployment in loops in 1989 occurred in feeder and distribution plant, the portions of the loops that extend "to the curb."

SOURCE: BOC data filed in Rate of Return Represcription proceeding, CC Docket No. 89-624 (Feb. 1990).

Table 4.5: Local Loop Working Channels by Type of Facility

Radio-based transmission systems also will have a major role in infrastructure development, including future loop designs. Even though fiber is replacing radio for many high-density traffic uses, the mobility that radio-based services permit makes such services increasingly attractive for customer loop applications. Dramatic growth in public mobile telephone and private radio services has occurred during the last 15 years.[427] Radio-based services like cellular networks interconnect to public networks through mobile switching offices, while some private networks do not. In particular, cellular subscribership has expanded from virtually nothing in 1983 to an estimated 5.3 million in 1990.[428] On the basis of a further allocation of radio spectrum in 1986,[429] and an interim industry technical standard,[430] cellular service operators are shaping their systems to accommodate further growth in subscribership.

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[427] For a discussion of land mobile radio services, their growth, and public policies shaping this growth, see *Telecom 2000, supra* note 17, at 283-304.

[428] Current growth rates are estimated to be more than 150,000 subscribers per month. Some observers predict (continued...)

The rapid growth of cellular service has generated substantial enthusiasm and activity in developing additional advanced wireless services. For example, a wide range of telecommunications service providers, including cable television companies, telephone companies, and other providers of radio-based services, are promoting the development of new radio-based "personal communications services" (PCS), based on a variety of new cordless technologies and advanced wireless systems.[431]

The technical and operational specifics of PCS, and its role in the telecommunications infrastructure, are not yet defined, although many proposed designs include a digital format using "microcell" transmission techniques.[432] Extensive radio frequency reuse associated with the small cell sizes and low transmitter power of PCS designs could conserve radio spectrum. From a total of 63 applications, the FCC has awarded 46 experimental PCS licenses through April 1991, including four licenses to cable television service operators. However, a number of issues must be addressed before PCS becomes a major component of the U.S. infrastructure, including the availability of radio spectrum for such services, the number of PCS providers that will be licensed in each community, and the relationship between PCS and other public and private network technologies.[433]

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[428] (...continued from preceeding page)
as many as 31 million cellular subscribers by 1995. *See Making the Transition to the New Network*, Telephony's Horizons of Technology, Feb. 1991, at 23.

[429] In 1986, the FCC allocated 10 MHz to cellular services from an established reserve allocation. This allocation supplemented a prior allocation of 40 MHz to cellular services.

[430] Originally, cellular systems were designed to use analog FM technology. This new interim digital standard (North American Digital Cellular Telephone Standard), based upon time division multiple access (TDMA) principles, is designed initially to increase the capacity of cellular systems three-fold. *See DSP May Spell Relief for Urban Cellular Congestion*, Telephony, Mar. 4, 1991, at 18-26. *See also* EIA/TIA Interim Standard 54 (May 1990) and Specification Drafts for Interim Standards 55 and 56 (completed Dec. 1990). In addition, the mobile radio industry is also interested in exploring the use of alternative digital transmission schemes, including the application of code division multiple access (CDMA) principles. CDMA land mobile radio systems, projected to have ten times or greater capacity than TDMA systems, are now being tested.

[431] *See Amendment of the Commission's Rules to Establish New Personal Communications Services*, 5 FCC Rcd 3995 (1990).

[432] Current cellular systems use cells that may cover a radial area of several miles. PCS microcells are envisioned to be much smaller, perhaps small enough to limit signal coverage to a single building.

[433] The resolution of these issues depends to a certain extent on whether one views PCS as a complement or a competitive alternative to existing wired local exchange networks or existing cellular networks. PCS potentially has the capability to serve any of these roles, which are not, in any event, mutually exclusive.

Successful development of such services would increase even further the importance of radio-based technologies in U.S. telecommunications.

In general, the traffic handling capabilities of transmission facilities have improved tremendously. New transmission systems have increasingly higher capacities, while signal processing techniques have been reducing substantially bandwidth requirements for voice and video messages.[434] These new transmission technologies have the potential for dramatically increasing customer choice and mobility in both public and private network schemes.

D. NETWORK SWITCHING

As with transmission systems, technical capabilities in network switching equipment have been increasing at an accelerating rate.[435] Witness, again, the blending of successive improvements in technology. Since the 1920s, when automatic "step-by-step" switching machines replaced systems that required human operators to establish connections, networks have incorporated a progression of more sophisticated switching equipment.[436] As the demand for telephone service grew, the efficiency, speed, and flexibility of the early step-by-step switches proved inadequate, and engineers developed a new generation of switches termed "crossbar systems."[437] Early crossbar switches employed a matrix of switching elements, using electromechanical relays, that could be operated much faster than step-by-step machines. Later crossbar switches used "common control" systems that shared control equipment, reducing the amount of such equipment required.[438] Crossbar switches had faster call set-up times, and lower maintenance costs than step-by-step switches. Telephone companies deployed crossbar switches widely over a thirty-year period, with installations occurring as late as 1976.[439]

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[434] *See supra* notes 402 and 403.

[435] Switching machines have two basic components. The switching component, or "switching fabric," consists of the actual elements used in making and breaking physical connections. The control component guides the operation of the switching component.

[436] The first automatic switching device was invented in 1881. Step-by-step switches, patented in 1889 and first installed in 1892, allowed customers to feed the called party's number directly to the switch to establish a connection. The control system of these electromechanical machines established a connection "progressively," actuating switching components in response to each digit dialed by the customer. Step-by-step switches were not deployed extensively by the Bell System until 1919 and, although succeeded by newer generations of equipment, these switches continued to be used in the United States into the 1980s.

[437] The Bell System used crossbar switching systems extensively. The No.1 crossbar, designed for large cities, was first installed in 1938. The No.5 crossbar, designed for smaller cities was introduced in 1948. The No.3 crossbar was developed in 1974 for service to rural areas. *See Noll, supra* note 390, at 96.

[438] Unlike progressive control systems, common control systems set up a connection, and then move on to the next call.

The next generation of switches, known as "electronic" or "stored program control" switches, was introduced in 1965 and relied on computer processing by stored software programs.[440] With this technology, transistor-based electronic switching elements were operated by common control systems, consisting of computer processors executing machine instructions based upon software commands stored in electronic memories. Changes in machine instructions could be "programmed" according to changing service needs. Essentially, an electronic switch is a special purpose computer that allows service features to be added or changed more easily and flexibly than with earlier switching equipment.[441]

All of the switches described above were analog switches. The next phase in the evolution of switching technology was the development of the digital switch. Digital switches combined stored program control with a switching fabric that allowed switching and processing of transmissions in a digital domain, creating a more cost-effective switching technology.[442] A key advantage of digital switches over their analog predecessors is a lower cost structure, in terms of both first costs per line and annual maintenance costs. Growth costs per line for digital switches can be as much as 30 percent less than those for analog switches. While it is possible to upgrade the performance of, and add advanced features to, analog switches, it is increasingly more cost effective to install a digital switch, rather than upgrade an existing analog switch, depending on the cost of specific analog upgrades. Since their appearance in 1976, programmable digital switches have become the equipment of choice for network expansion and large scale upgrades.[443]

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[439] In 1988, for example, about 32 percent of BOC switches were crossbar or other electromechanical switches, serving about nine percent of their access lines. *See Telephone Trends, supra* note 30, at 18, Table 13.

[440] While the subsequent discussion focuses on the development of new switch hardware, the increasingly important role of software should not be ignored. Software development today is central to the progress made in switching capabilities.

[441] Analog electronic switches in the United States, with appropriate hardware and software upgrades, are capable of providing advanced services. Even with the popularity of fully digital switches for new installations, vendors continue to develop digital adjunct equipment and software to upgrade the operation of existing analog switches, for use in situations that do not require fully digital switches. *See, e.g.*, Communications Daily, Mar. 6, 1991, at 5-6.

By year end 1988, over 67 percent of BOC switches were stored program control (both analog and digital), serving 91 percent of BOC access lines. About 29 percent of BOC offices contained analog, stored program control switches, serving 60 percent of their access lines. *See Telephone Trends, supra* note 30, at 18, Table 13.

[442] Flamm characterizes a digital switch generally as a device in which voice signals or data, encoded in a bit stream, are combined with some element of time-division switching. Time-division switching connections are established using time slots on a single physical path shared among multiple channels, while space-division switching uses physically discrete paths through separate communications channels. *See* Flamm, *Technological Advance and Costs: Computers versus Communications*, in *Changing the Rules: Technological Change, International Competition, and Regulation in Communications* 22 (R. Crandall and K. Flamm eds. 1989).

In addition to this analog-to-digital transformation, designers have developed different types of switches for different applications. For example, designers have created "remote" switches (controlled through larger switches) for small customer populations. For efficient use of multichannel digital transmission facilities, such as T1 plant, engineers have also developed digital cross-connect systems that permit the connection of multichannel trunks, or the interconnection of individual channels in trunks terminating on such systems.[444]

Evolution in public network switching has been matched by the development of switches for private applications—so-called PBXs. Today, the state-of-the-industry PBX is fully digital and can accommodate fiber transmission systems. Indeed, the robust competitive market for PBXs has fostered rapid introduction of advanced features and capabilities for such equipment.[445]

As commenters discuss, both public and private networks use digital switches for the vast majority of both new installations and replacements of older analog switches. Nevertheless, public networks currently contain a mix of several generations of switches, with older technologies being retired as newer technologies become cost competitive or are needed to meet the demand for new service features.[446] Moreover, regulatory developments have also affected switch deployment. For example, as noted earlier, requirements of the AT&T Consent Decree and the FCC that LECs provide "equal access" to IXCs resulted in widespread installation of electronic switches by the end of the 1980s. This growth is illustrated for the BOCs in Tables 4.6 and 4.7.[447]

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[443] Equipment modifications continue to improve the capabilities of digital switches. New hardware and software research is examining the switching of traffic moving at optical rates and handling more diverse traffic, including high speed data and video. Manufacturers such as Northern Telecom, with switches represented in its "FiberWorld" line of equipment, AT&T, with its 2000 series products (including switches), Siemens, Ericsson, and others are aggressively introducing digital switches designed to accommodate advanced fiber transmission systems.

[444] Digital cross-connect systems interconnect multichannel facilities, while switches interconnect individual lines. For example, digital cross-connect systems provide a connection between T1 circuits, allowing individual channels in these circuits to be split and recombined into different groupings onto another T1 channel. Cross-connect systems are also available for broadband signals.

[445] Ameritech asserts that PBXs now switch more lines (about 30 million) than even the largest telephone company. *See* Comments of Ameritech at 13.

[446] By 1989, the BOCs had converted 35 percent of their central offices to digital equipment, while independent telephone companies had converted 52 percent. Davidson and Dibble, *The Rural Challenge*, Telephony, Mar. 18, 1991, at 106. MESA estimates that 42.5 percent of LEC access lines were connected to digital (continued...)

COMPANY	1989		1994	
	TOTAL NUMBER OF OFFICES	% EQUIPPED FOR EQUAL ACCESS	TOTAL NUMBER OF OFFICES	% EQUIPPED FOR EQUAL ACCESS
Ameritech	1154	80.9	1154	98.2
Bell Atlantic	1321	92.4	1343	100
BellSouth	1651	84.9	1637	100
NYNEX	1327	71.3	1302	100
Pacific Bell/Nevada Bell	818	72.4	832	96.2
Southwestern Bell	1341	54.3	1336	96.1
US WEST	1777	55.5	1762	63.9
Total	9389	72.5	9366	92.1

SOURCE: BOC data filed in Rate of Return Represcription proceeding, CC Docket No. 89-624 (Feb. 1990).

Table 4.6: BOC Equal Access Deployment by Central Office

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[446] (...continued from preceeding page) switches in 1989, and projects that 68.2 percent of LEC access lines will be so connected in 1994. Management Education Services Assoc. Inc., *Comparative Assessment of National Public Telecommunications Infrastructures* (Apr. 1990) (submitted as Attach. 2 to Joint Submission of Bellcore) (*MESA Study*).

Bell Atlantic estimates that 50 percent of its lines have access to digital switching, while 99 percent are software controlled. *See* Mason, *The Bell Atlantic Way*, Telephony, Feb. 18, 1991, at 21. BellSouth, retiring its last electromechanical switch in 1990, has almost 49 percent of access lines served by analog switches and 51 percent served by digital switches. *See BellSouth 1990 Annual Report* 20. Indiana Bell will use electronic switches exclusively by the end of 1991. *Thoroughly Modern Indiana*, Communications Week, Mar. 11, 1991, at 32. Ameritech has digital switching in 70 percent of its offices, covering 40 percent of access lines. Rather than replace feature-rich switches in metropolitan areas, Ameritech often collocates a digital switch with existing analog switches. Ameritech may increase digital switch deployment in light of its announced plans to increase substantially its deployment of narrowband ISDN. *See* Wilson and Karpinski, *The 'Conservative' RHC Breaks the Mold*, Telephony, Apr. 22, 1991, at 36.

[447] "Equal access" is now available to approximately 90 percent of public network subscriber lines. *See Telephone Trends*, *supra* note 30, at 21, Table 15.

Table 4.8 shows the mix of stored program control and digital switches installed in the BOCs' networks in 1989, and provides projections for 1994. Table 4.9 depicts the percentage of BOC access lines that were served, or will be served, by stored program control and digital switches in the same two years. Within that five-year span, the number of digital BOC switches is projected to rise from 47 percent to 75 percent. Other LECs are also expanding digital offices rapidly. By 1994, GTE plans to serve 87 percent of its access lines from digital offices.[448] The increasing deployment of digital transmission plant beyond interoffice applications should continue to increase the replacement of electronic analog switches with the latest digital alternatives.[449]

COMPANY	1989		1994	
	TOTAL NUMBER OF LINES (000)	% WITH EQUAL ACCESS	TOTAL NUMBER OF LINES (000)	% WITH EQUAL ACCESS
Ameritech	15,872.6	96.4	17,661.8	100
Bell Atlantic	17,238.0	98.8	20,246.0	100
BellSouth	16,962.0	97.0	20,243.0	100
NYNEX	14,966.0	92.5	17,489.0	100
Pacific Bell/Nevada Bell	13,561.2	96.6	16,218.8	99.8
Southwestern Bell	11,644.7	88.9	13,290.0	98.9
US WEST	12,426.6	89.5	13,798.7	93.1
Total	102,671.1	94.7	118,947.3	99.0

SOURCE: BOC data filed in Rate of Return Represcription proceeding, CC Docket No. 89-624 (Feb. 1990).

Table 4.7: Equal Access (BOC Access Lines Served)

The development of so-called "advanced intelligent network" (AIN) technology also builds on the deployment of computer-controlled digital switching and advanced signalling technology in public networks.[450] Based on intensive work over the last decade, carriers and switch manufacturers have been able to identify a number of basic technical modules or operations that, in different combinations, comprise various services and features offered.[451] To permit greater user specification of services, designers are developing AIN capabilities to allow service providers to invoke, through the use of software, the proper combination of these modules to implement each service. Not only is this modular scheme designed to facilitate and speed the provisioning of services and features; technologists foresee the design of highly customized services tailored to individual needs.[452] In addition, AIN could allow carriers to mix switching and processing compo-

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[448] Comments of GTE Service Corp., App. D.

[449] Further technical improvements in switching might include upgrading capabilities of generic software programs, improving the processing capacity of control systems, and increasing the speed and volume of traffic being switched.

COMPANY	1989			1994		
	SPC (%)	DIGITAL (%)	TOTAL Offices	SPC (%)	DIGITAL (%)	TOTAL OFFICES
Ameritech	83.7	55.3	1154	98.4	98.4	1154
Bell Atlantic	96.3	65.9	1321	100	86.8	1343
BellSouth	88.0	62.1	1651	100	82.9	1637
NYNEX	69.9	46.7	1327	100	85.0	1302
Pacific Bell/Nevada Bell	74.0	42.7	818	94.5	66.9	832
Southwestern Bell	57.0	26.8	1341	98.5	74.4	1336
US WEST	53.1	32.4	1777	73.3	55.4	1762
Total	73.8	47.3	9389	94.1	75.3	9366

SOURCE: BOC data filed in Rate of Return Represcription proceeding, CC Docket No. 89-624 (Feb. 1990).

Table 4.8: Stored Program Control (SPC) And Digital Switching Equipment by Central Office

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[450] *See* Petition of the Coalition of Open Network Architecture Parties for Investigation of Advanced Intelligent Network (filed Nov. 16, 1990). Comments on this petition were filed on February 28, 1991; reply comments were filed on March 18, 1991. *See Pleading Cycle Established Comments on CONAP's Petition for Investigation of Advanced Intelligent Network*, 6 FCC Rcd 598 (1991).

[451] *See* Comments of PacTel at 22-24.

[452] *See* Titch, *AT&T Unveils AIN Line*, Telephony, Mar. 18, 1991, at 9. AIN will also reduce carriers' reliance (continued...)

nents from multiple suppliers. Thus, AIN developments could stimulate the introduction of new public network services and customized features, as well as improve the provisioning of existing services.[453]

COMPANY	1989			1994		
	SPC (%)	DIGITAL (%)	TOTAL LINES (000)	SPC (%)	DIGI-TAL (%)	Total Lines (000)
Ameritech	97.5	36.7	15,872.6	99.7	54.5	17,661.8
Bell Atlantic	99.3	41.1	17,238.0	100	65.5	20,246.0
BellSouth	97.7	44.1	16,962.0	100	66.7	20,243.0
NYNEX	89.9	48.6	14,966.0	100	70.7	17,489.0
Pacific Bell/Nevada Bell	93.8	28.2	13,561.2	99.1	43.1	16,218.8
Southwestern Bell	89.6	23.1	11,644.7	99.6	44.9	13,290.0
US WEST	88.4	29.8	12,426.6	95.6	44.0	13,798.7
Total	94.2	36.9	102,671.1	99.3	57.0	118,946.5

SOURCE: BOC data filed in Rate of Return Represcription proceeding, CC Docket No. 89-624 (Feb. 1990).

Table 4.9: BOC Stored Program Control (SPC) And Digital Switching Equipment Access Lines Served

Finally, a promising area of switching development involves "photonic" switches. All commercially-available switches to date switch electrical signals. To switch the optical signals now carried over fiber, current switches must first convert them to electronic form and then, after the signals have been processed through the switch, convert them back to optical form so that they can be transmitted again over fiber. A key objective of

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[452] (...continued from preceeding page)
on switch software releases from their principal switch suppliers. Titch, *The Pathway to Freedom*, Telephony, Apr. 15, 1991, at 30.

[453] Pacific Bell has announced a closed user test of the technology for June 1991. *See* Lanning, *Pac Bell Launches Major AIN Test*, Telephony, Feb. 18, 1991, at 9-10. Bell Atlantic is testing a programming language for service creation and service processing. Wilson, *The Public Network Gets Personal*, Telephony's Supercomm Wrap-up, Apr. 1991, at 31-32. Ameritech is conducting a technology trial with three switch vendors. Wilson and Karpinski, *The 'Conservative' RHC Breaks the Mold*, Telephony, Apr. 22, 1991, at 38. Other BOCs have also announced trial and deployment plans. *See* ONA Plan Amendments, FCC Docket No. 88-2 (filed Apr. 15, 1991).

photonic switch research[454] is to allow the large volumes of traffic that can be carried over fiber to be switched and processed optically or photonically, thus reducing the need for optoelectronic conversions.[455] The probable substantial future growth in fiber optic transmission plant could well lead to deployment of photonic switches.[456]

E. NETWORK SIGNALLING AND CONTROL FUNCTIONS

An important, but sometimes overlooked, element of network development involves network signalling capabilities. There are two functions for signalling. First, interoffice signalling provides the logic for information to be transferred across a network. It sets up and terminates connections, establishes routing, and creates billing or call accounting records. Second, interoffice signalling may draw information or instructions from a network database, or remotely monitor the operation of switching and other network equipment. Specialized interoffice signalling functions permit communication among networks. Customer-line signalling passes call status information (for example, off-hook, dial-tone, ringing, busy, on-hook), dialing information, and network information between networks and customers.[457]

For many years, signalling information was carried "in-band"—that is, over the same transmission channel as the customer's message.[458] The advent of "out-of-band" signalling in 1976 for AT&T long-distance service reduced call set-up time, promoted more efficient use of message circuits, and made possible the introduction of new services. Out-of-band signalling systems move information associated with each call in a packet format over packet-switching networks that are separate from the traditional message transmission networks. IXCs have moved aggressively to use the latest international standard for out-of-band signalling, Common Channel Signalling System No. 7 (SS7), which passes signalling information in a digital format. Following the extensive development of SS7 by long-distance carriers, local telephone companies and cellular service providers have developed plans to use SS7 in their serving areas to form a signalling network that passes network and call information to switch control equipment. For example, as shown in Table 4.10, the BOCs plan by 1994 to make SS7 available in offices serving about 73 percent of their access lines. GTE plans by 1994 to make SS7 available to 50 percent of its access lines.[459]

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[454] AT&T displayed the first working photonic switch in 1990. Wilson and Titch, *Applications to Take Spotlight at SUPERCOMM '91 Exhibits*, Telephony, Mar. 18, 1991, at 8. AT&T Bell Laboratories has incorporated photonic switching into an experimental PBX. Girishankar, *Photonic Switching*, Communications Week, Mar. 18, 1991, at 6.

[455] Such switching may be accomplished either by developing an entirely photonic switch, or by enhancing electronic technology to switch photonic traffic.

[456] Many experts believe that because of numerous technical obstacles, it will probably be the next century before such photonic switches are commercially available. *Looking Into the Horizon*, Telephony's Horizons of Technology, Feb. 1991, at 36.

[457] Signalling can affect the amount of delay experienced in call set-up. As calls typically now transverse multiple public and/or private networks, signalling improvements that minimize delay have become increasingly important.

[458] As noted above, early networks transmitted signalling information by manipulating direct current (DC) signals over trunks and lines. Newer systems use tone or digital signalling.

SS7 is designed to increase network efficiency, stimulate the development of new services, and also promote the introduction of AIN capabilities. A properly engineered SS7 system can minimize post-dialing delay, increase the efficient use of network equipment, facilitate distribution of intelligence throughout networks, and form the basis of new service offerings. SS7 allows the exchange and processing of network database information, including billing information, and routing and provisioning instructions, among stored program control switches. Since this signalling equipment allows information to be exchanged rapidly throughout a network, information and processing can be centrally located, or distributed according to traffic and demand patterns,[460] offering the potential to efficiently manage database storage and maintenance costs.[461] This, in turn, makes SS7-based networks more flexible and responsive to customer needs. For example, current equal access problems associated with the offering of "800" services can be addressed with the deployment of SS7.[462] The growth of services that depend upon network database information will amplify the importance of advanced signalling systems.[463]

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[459] Comments of GTE Service Corp., App. D.

[460] As we discuss in Chapter 6, plans to provide SS7 on a centralized basis have been limited by the restrictions of the AT&T Consent Decree. *See infra* notes 795-798 and accompanying text.

[461] The increasing sophistication of networks has also required upgrading the processing power of network control systems, also commonly described as "adding intelligence to networks." Between 1987 and 1989, MCI, for example tripled it computer processing power from 270 MIPS (millions of instructions per second) to 854 MIPS. *See* Comments of MCI Telecommunications Corp. at 26.

[462] SS7 permits the local exchange carrier to query a database to determine which IXC the 800 service customer (the called party) has selected to carry the call. Under current approaches, the IXC is identified by the first three digits of the called number. This that means particular 800 numbers are uniquely associated with particular IXCs and a customer cannot change IXCs without changing its number. Thus, the present 800 access system does not permit "number portability". The database system for 800 access also permits customers to use different IXCs for 800 calls depending on such factors as place of origination of the call or time of day it was placed. While a database query is technically feasible even without SS7, there is a significant increase in call completion time unless SS7 is available. Accordingly, the FCC has prohibited the LECs from implementing the database system for 800 access until there is a substantial level of SS7 deployment. *See Provision of Access for 800 Service*, 4 FCC Rcd 2824 (1989).

COMPANY	1989		1994	
	OFFICES (%)	LINES (%)	OFFICES (%)	LINES (%)
Ameritech	9.2	13.6	55.6	66.8
Bell Atlantic	34.8	60.3	91.3	99.0(a)
BellSouth	19.4	41.3	94.6	84.0(b)
NYNEX	0.0	0.0	75.2	89.1
Pacific Bell/Nevada Bell	5.4	14.7	34.0	85.0(c)
Southwestern Bell	0.0	0.0	24.9	66.5
US WEST	0.0	0.0	18.3	53.8
Total	9.9	21.0	57.0	72.9

(a) 1994 BOC technology deployment projection, based on Wallace is higher than that submitted in the Rate of Return Represcription proceeding, CC Docket No. 89-624 (Feb. 1990).

(b) 1994 BOC technology deployment projection, based on Wallace is lower than that submitted in the Rate of Return Represcription proceeding, CC Docket No. 89-624 (Feb. 1990).

(c) projection for 1995 is 94%, based on Wallace.

SOURCES: BOC data filed in Rate of Return Represcription proceeding CC Docket No. 89-624 (Feb. 1990); Wallace, *RBHCs Revise Schemes for ISDN Rollout*, Network World, Apr. 29, 1991, at 1.

Table 4.10: BOC Common Channel Signalling System 7 (SS7) by Central Office and Access Lines Served

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[463] SS7 can be configured to permit several different networks to operate compatibly. For example, trials are now underway to connect local telephone switches across New York State, allowing local and long-distance carriers and switch vendors to resolve SS7 connectivity issues. Brown, *First Phase of N.Y. ISDN Trial Completed with Ease*, Network World, Apr. 15, 1991, at 11. US Sprint and South Central Bell have recently interconnected SS7 facilities in Memphis. Molloy, *US Sprint Forges CCS7 Connection with BellSouth*, Network World, May 20, 1991, at 6. Engineering trials are also planned to test SS7 connectivity between cellular networks and wired public networks. Bushaus, *Three To Test SS7 Connection*, Communications Week, Apr. 29, 1991, at 43.

Customer line signalling—that is, the passage of signalling information from a customer's location to the first switch in the network—has evolved more slowly than interoffice signalling, due in part to the need to maintain highly standardized operational procedures familiar to end users.[464] Customer line signalling, including on-hook, off-hook, and ringing, is still commonly done by manipulating either in-band DC electrical signals or touchtone signals. Called number information is passed to the network by the "pulsing" DC current used in rotary dialing or by the multifrequency signals sent in touchtone dialing. With the separate, "derived" signalling channel now beginning to be offered as part of ISDN, customers will be able to signal the network during voice, data, or video communications, which could be useful in the operation of advanced features.

Operations and control systems also have developed to increase network reliability and efficiency. These management systems monitor, test, record, and permit manual or automatic adjustments in network operations. They can maintain traffic records, reroute traffic to avoid congestion, automate service provisioning, perform maintenance, and also detect, locate and correct the operation of faulty network elements.[465]

F. CUSTOMER PREMISES EQUIPMENT

Both public and private networks support and rely on a diverse variety of CPE, including wired and wireless telephone sets, key systems, PBXs, answering machines, facsimile (fax) machines, paging devices, videophones, data terminals, modems, multiplexing, and diagnostic and control equipment. While CPE traditionally has been analog, digital equipment is now being marketed to permit direct interfaces with digital transmission and signalling facilities. Moreover, CPE performs many of the functions formerly associated exclusively with public networks. PBXs allow switching functions to be localized in private networks, and also offer stable interfaces between public and private networks. The introduction of touchtone signalling in telephone sets has expanded the number of signalling options available to customers equipped with these relatively simple devices, permitting more complex interactions with switching equipment and user services like audiotex services.

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[464] The somewhat independent evolution of customer and interoffice signalling capabilities has been facilitated by the deployment of switches with common control systems that offer buffering between these signalling functions.

[465] *See, e.g., Rhyme and Reason: Artificial Intelligence in the Public Network,* Telephony's Horizons of Technology, Feb. 1991, at 32-33; *Carriers Strive for Full Integration,* Network World, Feb. 4, 1991, at 1-38.

The recent explosion in CPE development, which is due in substantial part to deregulatory activities by the FCC that resulted in intense CPE competition, has multiplied the communications options of users. Users, for example, now have a choice between wired or radio-based telephone sets for traditional voice telephony. Callers can record messages on answering machines at customer locations, or use network-based answering services. Fax machines, which permit rapid image transfer to take place, are now almost ubiquitous among business users and are beginning to penetrate the residential market as well.

The wide variety of CPE available provides opportunities and challenges for the development of telecommunication networks. CPE can be used to ensure the accuracy of transmissions and take advantage of the economies of multichannel transmission plant. Conversely, transmission networks must have the capabilities needed to support advanced CPE. Transmission networks also must be sufficiently flexible to accommodate diverse forms of CPE. As a result, a major challenge for policy makers is to ensure that regulation or other forms of government intrusion do not skew the development of network-based versus terminal-based functionality in a way that harms users.

III. NETWORK SERVICES, FEATURES, AND THEIR DEVELOPMENT

The telecommunications portion of the infrastructure—the transmission, switching, and terminal equipment that make up telecommunications networks—support a wide array of services. As the infrastructure changes, so too do the services provided through it. The expanding capabilities of public and private networks reflect choices made possible as a result of continuing technical progress. Competition in equipment and service markets is feeding this expansion. Public and private network services and features are developing in response to technical progress and changing demand. As the following subsections show, changes in the services and features available to users reflect, in part, changes in the underlying technology of U.S. networks.

A. CHANGING NETWORKS

As we have discussed, today's public and private networks are comprised of a wide variety of older, "mature" technologies and newer, highly advanced technical alternatives. As new technologies and media become cost-competitive compared to existing plant, they become preferred alternatives to the degree they increase the ease of accommodating new growth or adding service features. For wide-spread deployment, new technologies must also reflect lower total plant life cycle costs.[466] As a result of the wide variety of conditions in which U.S. networks operate, telecommunications services and features are built on and depend on a blend of new and older technologies, in a mix capable of delivering the desired performance (*e.g.*, in terms of capacity, accuracy, or speed) at a particular cost.[467]

B. CHANGING DEMAND AND SERVICE EVOLUTION

Voice traffic is still the principal component of residential and business traffic over public and private networks,[468] and thus continues to exert a strong influence on network planning. For example, LECs have made single party telephone service very widely available, reducing multiparty service to about 2.5 percent of access lines.[469] Specialized forms of voice services, such as 800 and 900 services, have grown rapidly in popularity over the past decade.[470] To supplement traditional voice services, however, users are demanding a host of other options, including call handling features,[471] call conferencing, facility control[472] and switching functions, and traffic aggregation capabilities.

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[466] The installation of new equipment to accommodate service growth or to replace fully depreciated facilities is a fairly straightforward investment decision. More difficult is the decision to accelerate the retirement of facilities for the purpose of installing new equipment with greater functionality or lower life cycle costs than equipment being replaced. This latter decision must consider additional factors, including the cost of depreciation shortfalls and the probability that demand for new functionality will be sufficient to cover new equipment costs.

[467] USTA proposes infrastructure sharing among LECs, to permit "prompt and cost-effective deployment of new services and technologies." Under such an arrangement, switches "constructed by one company can be used to serve subtending offices of other companies in an architecture designed to maximize the overall efficiency of the exchange network." *See* Comments of USTA at 36-37. This concept is similar to the more general interconnection policies we advocate in Chapter 6. *See infra* at 283-285.

[468] Eigen, *Narrowband and Broadband ISDN CPE Directions,* IEEE Communications Mag., Apr. 1990, at 39.

[469] *See* Hudson and Parker, *Information Gaps in Rural America,* 14 Telecommunications Pol. 198 (1990). In contrast, in 1950, multiparty lines outnumbered single party lines by a ratio of more than five to one. *Bell System Statistical Manual, 1950-1981* at 505, 517 (June 1982).

[470] Although 900 service offerings are more recent than 800 services, initial growth has been rapid. Growing from initial efforts in 1987, 1,000 service providers operate about 7,000 lines that generate an estimated $1 billion. *See, e.g.,* Diamond, *900 Numbers Should Answer to New Rules,* L.A. Times, Feb. 22, 1991, at D1.

[471] Advanced call handling service features include those that reveal the caller's identity (*e.g.,* by listing the telephone number or through distinctive ringing), and permit call forwarding (all calls or selected calls), call blocking, repeat call, call trace, abbreviated dialing (speed calling), or indicate a waiting call.

[472] *See e.g.,* Reisfield, *Customers Take Control of the AT&T Network,* 6 AT&T Technology 44-48 (1991).

Commenters also have described demand for such features as expanded directory assistance and emergency services for the disabled and non-English speakers.[473] As importantly, residential and business users are increasingly demanding mobile capabilities.

While voice calls continue to represent the largest share of traffic on most networks, data communications traffic has grown dramatically with the increasing presence of computers and data processing in everyday life.[474] As a result, users are demanding networks that send larger quantities of data at faster rates than previously required.[475] Moreover, users are increasingly demanding the transport of images, either fixed or in motion, with reproduction in hard copy or video form. Such demand has fueled spectacular growth in fax equipment sales.[476] Videoconferencing, a video service still in its infancy, may develop with improvements in performance and falling service costs.[477] Demand for video entertainment has fed the growth of cable television, and has increased LEC interest in providing video programming in their service areas, an activity from which they are currently barred by the Cable Act of 1984 and FCC rules.[478]

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[473] *See* Comments of REA at 12-13; Comments of Cincinnati Bell Telephone Co. at 12.

[474] Roughly 24 percent of the nation's 94 million households (22.6 million households) are now equipped with personal computers. *See 1991 Industrial Outlook, supra* note 371, at 28-8 to 28-9. Some one-third of those homes may also own modems. *See* Comments of CompuServe Inc. at 6 n.5.

[475] Industry revenues from data transmission have grown from $9.5 billion in 1987 to an estimated $13 billion in 1990. Revenues for 1991 are projected to grow more than 12 percent. *See BellSouth 1990 Annual Report* 12.

As a result, LECs are developing metropolitan-wide public network services to offer bandwidth on demand, through proposed services like SMDS, at capacities up to 45 Mbps. SMDS will be offered in Philadelphia in 1991 and in other cities during the following year. Other LECs and long-distance carriers are now testing SMDS. *See* Emigh, *New SMDS Applications Bloom in Nynex Boston Trial,* Telephony, Apr. 1, 1991, at 8-9; Taff, *MCI Plans Trials of Long-Distance SMDS,* Network World, Mar. 25, 1991, at 1; Wallace, *Several RBHCs Announce Progress on SMDS Devices,* Network World, Mar. 25, 1991, at 4; *Wideband for the 1990s: Smarter, Leaner, and Cheaper,* Networking Management, March, at 70-77.

Innovative long-distance services are developing as well. For example, AT&T has announced a Software Defined Data Network offering allowing 384 Kbps "dial up" service on AT&T Software Defined Network. *See* Communications Daily, Apr. 11, 1991, at 5.

[476] Fax machines in the domestic market are projected to grow from 4.6 million in 1990 to 5.9 million in 1991. *See BellSouth 1990 Annual Report* 12.

[477] After several false starts, there appears to be renewed interest in videoconferencing. AT&T reports that its videoconferencing traffic has grown 50 to 60 percent each year for the last two years. *See The Video Boom is Here,* Networking Management, Apr. 1991, at 50. Videoconferencing revenues have been estimated at $202.7 million and $335.8 million for 1989 and 1990, respectively. *See* Karpinski, *Video Applications Come Into Focus,* Telephony's Supercomm Wrap-up, Apr. 1991, at 22. *See also,* Schwartz, *Videoconferencing Still Too Pricey,* Communications Week, Apr. 22, 1991, at 26.

[478] *See* 47 U.S.C. § 533(b) (1988); 47 C.F.R. §§ 63.54-63.58 (1990). We discuss this restriction in detail in Chapter 6.

Residential users obtain service primarily from the public networks of traditional common carriers. Many businesses meet their needs through public networks, which may include the facilities of both traditional common carriers and alternative service providers. Businesses may also build private networks that combine network equipment purchased competitively, and private line services obtained from common carriers. Further, private network users commonly interconnect their facilities to public networks for wider communication.

The changing mix of customers and customer needs has motivated new firms to enter telecommunications markets, to the extent that open entry is permitted. Indeed, competition has been increasing the number of public networks. The FCC has identified some 448 firms as currently competing in interexchange markets.[479] Some of these providers focus primarily on price competition for switched and special services, while others focus on superior private line service performance guarantees (*e.g.*, provisioning speed, outages, transmission error rates), desirable features such as self-healing systems, and transmission paths physically independent of competitors' facilities.[480] Similarly, competition is growing in a limited part of the local exchange market, principally for providing high-bandwidth access from the user's premises to long-distance carriers. Many of these competitors' networks and business strategies are based on the use of fiber optics for high density transmissions.

Moreover, as home computer use becomes more prevalent,[481] customers are demanding user-friendly gateways, offering access to information service providers.[482] These providers already offer such services as database retrieval, voice messaging, and credit verification. Information service providers are themselves major users of public network services and features, because public networks and gateways permit these providers to obtain wide access to customers. The needs of information service providers and others are stimulating the development of new interconnection arrangements and the offering of network capabilities previously available only to public carriers. Information service providers can build their offerings on BOC services made available in response to the FCC's Open Network Architecture (ONA) process, including public network signalling capabilities, automatic number identification, answer supervision, warm line, and loopback testing.[483] Such information is passed through standardized interfaces between the information service providers and the BOCs.

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[479] *See* Industry Analysis Division, Common Carrier Bureau, Federal Communications Commission, *Summary of Long Distance Carriers* 6 (Feb. 28, 1991).

[480] *See* Wallace, *Dissatisfied Users Looking Beyond Bells,* Network World, Apr. 8, 1991, at 13-14; Bushaus, *User Issues: Service Local Competition,* Communications Week, Mar. 4, 1991, at 8.

[481] *See supra* note 474.

[482] *See* Comments of CIRI at 10; Comments of Direct Dialogue Council at 1; Comments of the State of Minnesota at 12; Comments of USTA at 3-4; Comments of BellSouth Corp., App. H at 16-24; Comments of REA at 12; Comments of Cincinnati Bell Telephone Co. at 12; Comments of TDS at 53-54; Comments of Pacific Telecom, Inc. at 5; Comments of KPMG Peat Marwick at 3; Comments of SNET at 44.

As mentioned previously, public and private radio-based services have developed sufficiently to become viable "untethered" options for business and residential consumers. To meet the additional needs of a mobile society, technologists are developing transportable user profiles. At the present time, a user's billing information, long-distance presubscription choices, and basic service and call-handling features are identified with a specific "user location" in a network—that is, the location of the user's terminal device. New network plant, including innovative databases, processing, AIN capabilities, and signalling technology, will permit users to install and activate their profiles on any compatible network terminal, wired or wireless.

Work by international technical standards groups is attempting to define this concept formally. For example, Universal Personal Telecommunications (UPT) is a service proposed to enable access to telecommunications services by allowing personal mobility. Each UPT user would be able to participate in a user-defined set of subscribed services, and to initiate and receive calls on the basis of a unique, personal, network-independent UPT Number across multiple networks. UPT users would be accessible through any terminal, fixed, movable or mobile, irrespective of geographic location, limited only by terminal and network capabilities and restrictions imposed by the network provider.[484] By activating these profiles as users move from location to location, networks can track user movements and route calls to the proper terminals.[485] Users can also make use of their customized set of service features at each activated terminal.

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[483] Public carriers use these functions and others to set-up and terminate calls, assign charges, test plant, and administer network operations. For an overview of the ONA requirements applicable to the BOCs, see *Filing and Review of Open Network Architecture Plans*, 4 FCC Rcd 1 (1988), *recon.* 5 FCC Rcd 3084, *further recon.*, 5 FCC Rcd 3103 (1990).

[484] *See* CCITT Study Group I, *Proposed Definition* (Nov. 1990); (Recommended by Associate Rapporteur Mar. 13, 1991).

[485] With the development of national or international rerouting capabilities, there will be important implementation questions to resolve. For example, if a call to a friend who is usually across town is rerouted across the country, should the caller be notified if a different rate is in effect? Should the calling party be notified that the call is being rerouted? Should the network identify the new location of the called party?

The current expansion of service options, fueled both by demand and by technological developments, seems certain to continue in the future.[486] A challenge for the industry is to develop compatible technical platforms with sufficient flexibility to serve these needs; the corresponding challenge for policymakers is to structure the regulatory and legal environment to permit such flexibility to develop.

IV. NETWORK EVOLUTION: ISSUES

With the rapid pace of technical progress, investment decisions regarding telecommunications facilities must accommodate the changing nature of demand. Furthermore, such decisions must consider how adaptable networks will be in meeting that changing demand, and judge when plant replacement (as opposed to plant modification) is appropriate. Implementation issues and technical standards questions also affect the choice of technologies. While network operators, equipment manufacturers, and users will clearly play primary roles in resolving key technical issues and meeting the challenges of implementing network modifications, some government action may be helpful in this process.

A. IMPLEMENTATION

Investment decisions often require network operators to balance their commitments to current technology with the anticipated development of better technologies in the future. This choice is difficult, in part because of the large scale of telecommunications investments.[487] Some technologies require substantial deployment to support a new service. For example, to be economically justified, new call handling services may require a new signalling system to be deployed throughout a service area, with software installed in every serving switch. But such large-scale technology deployment decisions should not be so inflexible as to foreclose future investment decisions that may depend on technology still under development. Today's technology implementation scheme must anticipate and provide, not foreclose, opportunities to develop tomorrow's services, built on future technology. The development of "advanced" capabilities must permit a reasonably smooth evolution of technical improvements to maintain a continuing healthy mix of up-to-date technology.

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[486] For a forward-looking discussion of new services and options, see Williams, *The Coming Intelligent Network: New Options for the Individual and Community, Institute for Communications Studies—The Annual Review 1990.*

[487] The scale and costs of such investments may create the need for extensive cooperation among telecommunications firms so that the services and capabilities that those investments make possible will be accessible to telecommunication providers of all size. For example, a small LEC, alone, may be unable to justify deployment of an information service "gateway" in its operating area because it may lack a sufficient customer base to defray the capital costs of that gateway. If that LEC could "share infrastructure" by accessing the gateway of another, perhaps larger LEC in a nearby territory, the smaller LEC could share the costs of making gateway capabilities available within its territory and thereby, provide services that would otherwise be unavailable. *See* Comments of USTA at 36-37. *See also* Comments of Leland Schmidt at 1, 3-6. To ensure broad availability of advanced equipment and services, policymakers should, consistent with the antitrust laws, encourage such infrastructure sharing between and among LEC and other telecommunications providers.

Moreover, the use of new technologies can increase options and opportunities for users, raising issues of network control. The development of sophisticated CPE is enabling customers to control public network functions, traditionally under the network operator's control. Intelligence in CPE, for example, could allow customers to perform loopback testing, multiplexing, and interact with network intelligence, all functions that at one time were controlled only by the network operator. The possibilities for flexible distribution of control and "intelligence" among CPE and public and private networks are a source of some tension among network operators, users, and equipment manufacturers, but also present opportunities for flexible service offerings if all interconnected equipment can work together.[488]

Similarly, technical and market developments are raising questions concerning operation of the current numbering plan for U.S. telecommunications, as well as future "number planning."[489] Public network providers rely on specific numbers or specific designations in a caller's dialing sequence to identify the type of call, billing arrangements, and even the carrier to be used.[490] The proliferation of telecommunications competitors, both wire-based and wireless, and the growth of new services is increasing the complexity of number planning. A important challenge for the industry is to evolve number planning activities to accommodate these developments in a manner that promotes competitive market developments, and gives customers access to these options, while preserving dialing convenience.

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[488] AT&T suggests that future networks will distribute service logic throughout entire networks, expanding upon the traditional practice of locating network intelligence in switching systems. *See* Robinson, *Service Net-2000: Framework for Tomorrow's Network*, 5 AT&T Technology 38 (1990). Indeed, policymakers will have to be increasingly sensitive to protecting the privacy interests of both telecommunications service users and providers as the distribution of control shifts.

[489] The format and designation of caller dialing numbers is coordinated both nationally and internationally. The CCITT on behalf of the ITU coordinates international calling numbers identifying each country. Bellcore administers the national numbering plan.

[490] For example, local, long-distance, and international calls require differing number dialing sequences. Certain numbers and sets of numbers are reserved for operator, emergency, audiotex, and toll-free services. With the development of "equal access" to long-distance services, a caller can select from a variety of carriers for each call or opt for the use of a pre-assigned carrier.

The use of new technologies may raise additional implementation questions for network designers. A good example of this phenomenon for public network designers is the question of "powering" terminal equipment to be used with fiber optic loop transmission systems. In conventional copper-based public networks, LECs supply power to customer telephones through copper loop plant.[491] In the event of an outage of the electrical system at a customer's premises, the telephone service will continue to work.[492] Since fiber transmission systems do not conduct electric current, network designers contemplating fiber to the home must decide whether to convey power over separate copper plant, obtain power from the customer's supply, with battery backup, or devise some other alternative.[493]

In order to use broadband facilities efficiently, technologists are devising methods to transport voice, data, and video in a integrated fashion through the same switches and transmission media. With digital technology, all three forms of information are first encoded into digital bit streams, which are then transmitted through the network. While the bandwidth required for these different uses can vary substantially, the basics of digital transmission are essentially the same, creating the possibility of "integrated" networks which can increase the efficiency and flexibility of the services delivered to the customer (as compared with having to build separate specialized networks for each application).

Nevertheless, there are some design tradeoffs in such integration. For example, in order to function correctly, integrated transmission plant must meet the design constraints associated with voice, data, and video traffic. Although these forms of information are all transmitted as digital bit streams, they have different "customer use" characteristics that would normally dictate different network processing treatment. Data are typically conveyed at very low error rates to reduce the amount of retransmission required while maintaining accuracy, but often can permit occasional periods of delay in transmission.[494] In contrast, while digital transmission of voice and video can tolerate some degree of error (in part, because the human ear and eye can correct for some errors and understand the message being delivered), transmissions not conveyed within tight time constraints will require buffering and could result in message loss.

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[491] Early telephones were first equipped with "wet-cell" batteries, prior to the development of dry batteries. Later improvements supplied power to telephones from a common battery located at the local switch.

[492] Under this arrangement, if the telephone company also loses power in an outage, service is maintained by using battery backup at the switching office.

[493] These alternatives raise issues of who controls, and pays for, such power supplies. Various approaches have been tried in different trials, including end user provided power with battery backup and power pods located in network remote switching units. No clear preferred solution has emerged. Davis and Jander, *Fiber in the Local Loop Spawns Power Concerns*, Telephony, Apr. 29, 1991, at 24-28.

B. NETWORK RELIABILITY

Managing the operation of complex broadband networks is another challenging activity. Since increasingly large volumes of traffic are moving through broadband transmission and switching facilities, a failure in one of these components could potentially result in a large service outage. Trouble may result from a variety of circumstances.[495] A May 1988 fire in an Ameritech switching facility in Hinsdale, Illinois, caused a service interruption to 35,000 customers for several weeks.[496] In January 1990, a software error in an AT&T switch disabled AT&T's network for nine hours.[497] In January 1991, an accidental cut in an AT&T fiber optic cable in New York City caused the closure of the New York Commodity Exchange and Mercantile Exchange, delayed air traffic at the metropolitan area's three major airports, and interrupted service into and out of the city for eight hours.[498] In March 1991, a cut in a Pacific Bell fiber optic cable knocked out 54,000 circuits.[499]

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[494] Using current methods, errors detected in data transmission require retransmission.

[495] To address such possibilities, network providers are planning alternative switching and transmission paths through which to route traffic diverted from trouble points. *See, e.g.*, the network protection tariff described in *TARIFF TRENDS: Interexchange Carriers Offer Protection from Network Disruptions*, Networking Management, Mar. 1991, at 12. NYNEX, Bell Atlantic and US West have also announced disaster-recovery service offerings. *See Preparing For The Worst*, Communications Week, Feb. 25, 1991, at 12; Schwartz, *Call-Protection Plan*, Communications Week, Feb. [illegible], at 2; Kozak, *Alternate Local Access Via Fiber*, Telecommunications, July 1990.

In addition, network designers are developing systems to enhance their ability to diagnose, maintain, and operate network plant. Further deployment of broadband facilities will increase the scope of contingency planning efforts. Increasing network complexity will demand more sophisticated operational, diagnostic, and control equipment. Moreover, development of "self-healing" networks and network diagnostic "expert systems" is growing in importance as our networks become increasingly diverse and complex. US West has announced a self-healing service for switched services, supplementing service currently available to private line customers. *See* Karpinski, *US West Sends ...SOS' to Aid IXCs*, Telephony, May 13, 1991, at 3.

[496] Swanson and Karwath, *Phone Service Taking 1st Steps Back to Normal*, Chicago Trib., May 11, 1988, at 1.

[497] In addition, recent efforts to use 800 services for conducting high-visibility advertising promotions have raised network capacity issues. For example, a proposed Super Bowl promotional spot for Pepsi-Cola was never aired in part because of such concerns. Ramirez, *Pepsi in a Super Bowl Rush After Scrapping Its Contest*, N.Y. Times, Jan. 26, 1991, at 31. *See also Users Would Welcome LEC Competition*, Telephony, Mar. 4, 1991, at 10-14.

In June and July 1991, defects in the software that controlled Pacific Bell's and Bell Atlantic's SS7 networks triggered service disruptions in Los Angeles, San Francisco, Pittsburgh, the District of Columbia, as well as in Maryland, Virginia, and West Virginia.[500] In September 1991, a power failure in an AT&T switching center in New York City blocked long distance calls, delayed Federal Reserve wire transfers, and seriously disrupted national air traffic for more than six hours.[501] Less than a week later, a cable cut in Miami, Florida, shut down Miami International Airport for several hours.[502]

It should be noted, however, that these failures occurred in the context of a U.S. telecommunications system that, on an overall basis, has a track record of high quality and reliability. Call completion rates in the United States are now in the neighborhood of 99 percent.[503] Moreover, the outages cited were largely the result of human errors: cable cuts, faulty software development and insufficient testing, and failure to adhere to company operating procedures. It is not clear that such errors are attributable to government regulations and policies, nor is there reason to believe that government action would have prevented them from occurring.

Nevertheless, because of the growing importance of telecommunications to the U.S. economy, and to public health and safety, service outages have increasingly severe consequences. Accordingly, steps should be taken both to reduce the chances of such outages occurring and to lessen the customer dislocations if disruptions do occur. We note initially that some observers argue that competition can degrade the reliability of telecommunications services, by, for example, causing firms to place too much emphasis on reducing costs. In our view, this criticism of competition is misplaced. NTIA believes that, to the contrary, competition in telecommunications services markets will give firms strong incentives to provide high quality, reliable service, or risk losing customers to rival companies.[504] Thus, firms subject to competition can be expected to make investments and establish procedures that will minimize potential service outages. Moreover, increased competition will "enable users to add redundancy and security to every portion of their network."[505] As a result, such users will less affected by a service outage suffered by any one of their providers.

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[498] Bradsher, *AT&T Cable Severed, Snarling New York Long-Distance Calling*, N.Y. Times, Jan. 5, 1991, at 1.

[499] Communications Week, Apr. 8, 1991, at 24.

[500] *See* Common Carrier Bureau, Federal Communications Commission, *Preliminary Report on Network Outages* (released July 29, 1991). Telephone calls routed through single switching offices as well as incoming long distance calls were not affected. Outbound long distance and local interoffice telephone calls could not be completed because of faulty instructions introduced when changes in switching software were made to improve network performance.

[501] Keller, *AT&T Phones Fail in New York, Disrupting Nationwide Air Traffic*, Wall St. J., Sept. 18, 1991, at B1.

[502] Opening statement of Rep. Robert E. Wise, Jr. in Hearings Before the Subcomm. on Government Information, Justice and Agriculture of the House Comm. on Government Operations, 102d Cong., 1st Sess., at 1 (Oct. 2, 1991).

[503] *See infra* at 197, Table 5.21.

Although increased competition provides powerful incentives for maintaining high quality networks, it does involve an expansion in the number and types of networks and providers that could increase the complexity of ensuring certain aspects of overall service reliability.[506] We believe that this complexity can be addressed by increasing the flow of information about network problems between government and private firms, as well as among the firms themselves. Through this process, regulators can gather vital information about when service disruptions occur, how they happen, and how they affect users. Regulators should also encourage and, if necessary, insist upon the exchange of information among service providers that can help warn firms about when or where outages or disruptions may occur, how they can be corrected and, more importantly, how they can be avoided.

For example, the FCC recently proposed to require that all facilities-based carriers providing interstate or international services promptly notify the FCC of "incidents during which service to 50,000 or more of its customers or voice grade equivalent circuits is disrupted for 30 minutes or more."[507] The FCC has also requested comments on whether and to what extent this information should be shared with other parts of the telecommunications industry, such as regulatory commissions in states where outages occur, or with other telephone industry representatives.[508] Further, the Exchange Carrier Standards Association, through its Network Operations Forum, "has undertaken defining what a service outage is, when outages should be reported to others in the industry and to whom such reports will be made."[509] NTIA believes that by promoting the collection and dissemination of information about network disruptions, these initiatives could enhance network reliability, even in an increasingly competitive market environment. In addition, we note in Chapter 6, incentive regulation, where applicable, can be tailored in certain respects to promote reliability.[510]

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[504] *See id.*; Testimony of Rob McCrory, Tele-Communications Ass'n, before the Subcomm. on Telecommunications and Finance of the House Comm. on Energy and Commerce, 102d Cong., 1st Sess., at 5 (Oct. 1, 1991).

[505] *See id.* at 8. *See also* Skrzycki and Phillips, *Human Error Led to Outage, AT&T Says; Technicians Failed To Heed Alarms,* Sept. 19, 1991, at A1; Comments of MFS at 22-29. *But see infra* note 974.

[506] *See, e.g.*, Testimony of Eli M. Noam, Columbia University, before the Subcomm. on Government Information, Justice and Agriculture of the House Comm. on Government Operations, 102d Cong., 1st Sess., at 1 (Oct. 2, 1991).

[507] *Amendment of Part 63 of the Commission's Rules to Provide for Notification by Common Carriers of Service Disruptions,* CC Docket No. 91-273, FCC 91-285, para. 1 (released Sept. 19, 1991). The FCC has also established "a multidisciplinary staff . . . to specifically investigate individual incidents as well as to more broadly address network reliability." Testimony of Richard M. Firestone, Chief, Common Carrier (continued...)

Although important, these government and industry initiatives are no substitute for a strong, continuous commitment to quality and reliability on the part of carriers and other service providers. Those firms must not only adopt clear, effective procedures to minimize service disruptions; they must also ensure that their employees are familiar with such procedures and follow them.[511] Moreover, in addition to general concerns about network reliability and security, the industry should pay particular attention to safeguarding advanced signalling system operations since they will increasingly perform the "central nervous system" functions of public networks.[512] Analysis of the recent

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[507] (...continued from preceeding page)
Bureau, FCC, before the Subcomm. on Telecommunications and Finance of the House Comm. on Energy and Commerce, 102d Cong., 1st Sess., at 9 (Oct. 1, 1991).

[508] *See Amendment of Part 63 of the Commission's Rules to Provide for Notification by Common Carriers of Service Disruptions,* CC Docket No. 91-273, FCC 91-285, para. 5 (released Sept. 19, 1991).

[509] Statement of Casimir Skrzypczak, Chairman of the Board of Directors, Exchange Carrier Standards Association, before the Subcomm. on Government Information, Justice and Agriculture of the House Comm. on Government Operations, 102d Cong., 1st Sess., at 17 (Oct. 2, 1991).

Bellcore is also developing a proposal for an improved, industry-wide testing capability "where equipment and software can be tested in a more life-like, interconnected multiple network environment." If implemented, this program can promote service integrity by allowing equipment and capabilities (such as signalling systems) to be tested in different settings and under different conditions before they are integrated into the system. *See* Testimony of Dr. Irwin Dorros, Executive Vice President, Technical Services, Bellcore, before the Subcomm. on Telecommunications and Finance of the House Comm. on Energy and Commerce, 102d Cong., 1st Sess., at 16 (Oct. 1, 1991).

[510] *See infra* note 915.

[511] *See* Statement of Kenneth L. Garrett, Senior Vice President—Network Services, AT&T, before the Subcomm. on Telecommunications and Finance of the House Comm. on Energy and Commerce, 102d Cong., 1st Sess., at 23 (Oct. 1, 1991).

[512] A 1989 National Research Council (NRC) study of public network vulnerability identifies, in addition to a technical trend toward diminishing network route diversity, a growing reliance on "very thin" advanced signalling networks and a small number of large databases. Hardware failures or software problems (continued...)

disruptions associated with advanced software suggests that carriers and vendors should test all software network additions, regardless of size, prior to their introduction into public networks, to reduce the possibility of service outages.[513] In the final analysis, vigilance by the firms themselves will provide the greatest safeguard for network reliability.

C. STANDARDS DEVELOPMENT

The growth of competition in service and equipment markets and the pace of technical development underscore the importance of standards development for customers and the industry.[514] Standard interfaces and protocols can make it easier for public and private networks to pass traffic and signalling across network boundaries. Public network providers coordinate their interactions and improve service quality with the proper use of standards. With proper standards, other service providers could use network-provided technical modules[515] or "building blocks"[516] to develop information services for consumers. By defining stable interface points and organizing the passage of traffic and signals across these points, the industry can facilitate the interworkings of various industry segments competing in the marketplace, both in day-to-day operations and in the face of technical change.[517]

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512 (...continued from preceeding page)
introduced inadvertently or through malicious behavior could dramatically degrade the performance of public networks, without adequate safeguards as suggested by the NRC. National Research Council, *Growing Vulnerability of the Public Switched Networks: Implications for National Security Emergency Preparedness* 3, 56-57 (1989).

[513] Prior to the recent disruption, the advanced signalling system equipment vendor provided its telephone customers with software changes judged to be too small to require major testing. Burgess, *Tiny 'Bug' Caused Phone Blackouts*, Wash. Post, July 10, 1991, at A1.

[514] Carlton and Klamer discuss the tension between efficiency gains from coordinated activities such as standards-making and the loss in competition that may result. Carlton and Klamer, *The Need for Coordination Among Firms, with Special Reference to Network Industries*, 50 Univ. of Chi. Law Rev. 446 (1983).

[515] *See supra* notes 450-453 and accompanying text.

[516] The FCC has reinstated ONA obligations on the BOCs and AT&T. *See Computer III Remand Proceedings*, 5 FCC Rcd 7719 (1990). ONA requirements, as described in prior FCC-approved plans, call for the BOCs to offer network functionalities called "basic service elements" through connection arrangements called "basic serving arrangements." *See Filing and Review of Open Network Architecture Plans*, 4 FCC Rcd 1, 17-22 (1988).

[517] NTIA discussed the benefits and disadvantages of standards generally in our recent report on spectrum management policy. *See Spectrum Report, supra* note 13, at 68-78.

Standards can also benefit private and public network operators. With standard interfaces for networks, network operators can change specific components, taking advantage of improvements in technology, without extensive network modifications.[518] Advantages can also accrue to equipment manufacturers, which can bring individual pieces of equipment to the market without introducing a complete new family of network equipment. Manufacturers also can make internal improvements to individual devices as long as compatibility requirements are met.[519]

1. Standards and Technological Trends

The robust U.S. telecommunications industry has stimulated substantial standards development activities. For example, the proliferation of fiber optic transmission systems and the demand for high bandwidth transmission capabilities have led U.S. industry to develop Synchronous Optical Network (SONET) standards. SONET standards will allow fiber optic transmission equipment and high bandwidth digital equipment built by different vendors to be used together efficiently and with low transmission error rate performance.[520] The SONET standards already specify physical and hardware requirements. Also under development are communications protocols that will allow better management and monitoring of network performance. These standards should facilitate the further development and use of fiber optic equipment.[521]

The topics addressed in standards-setting bodies provide an indication of technological trends in communications. Staff from NTIA's Institute of Telecommunications Sciences participate actively in such activities. Based on their observations, current domestic and international standards activities appear to reflect increased future reliance on the following capabilities, many of which we have discussed above:

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[518] Stable interfaces at network boundaries also permit independent changes in network equipment and terminal equipment that are compatible with these interface standards.

[519] Even while acknowledging the benefits of standardization, Besen and Saloner discuss reasons why there is no guarantee that standardization will be achieved or that the "right" standard will be chosen. Besen and Saloner, *The Economics of Telecommunications Standards*, in *Changing the Rules: Technological Change, International Competition, and Regulation in Communications* 177-220 (R. Crandall and K. Flamm eds. 1989).

[520] SONET-based technology is being designed for systems able to transmit very high volumes of traffic, ranging from more than 50 Mbps to 13 Gbps.

[521] Various manufacturers have announced the development of SONET products and field trials. *See* Warr, *SONET: A Status Report*, Telephony, Jan. 28, 1991, at 25-28. Network operators have begun to install SONET-compatible equipment. *See* Brown, *Teleport-Chicago Says Its Net is First Based on SONET*, Network World, Apr. 15, 1991, at 2.

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- Digitization of networks and higher capacity of signalling, switching, transmission, and terminal components, with the design goal of meeting user needs by providing greater flexibility, accuracy, and efficiency.

- Separate, out-of-band signalling networks, such as SS7, to speed call processing by several orders of magnitude and increase the efficient use of network resources.

- Greater user control of network facilities and a variety of integrated voice, video, and data services, perhaps including services that can be customized for each call.

The substantial standard-setting and technical activity in these areas suggests that the greatest question concerning such developments is when we will have them.

2. The Standards Process

The U.S. standard-setting process for network services and equipment is, for the most part, a cooperative, voluntary effort. Similar to many other industries, there is a presumption regarding telecommunications standards that their development should rely on privately created, voluntary standards activities.[522] Prior to AT&T's divestiture in 1984, the Bell System set most *de facto* public network technical standards for telephony. Since 1984, standards work in telecommunication continues to be principally a private sector activity, with the addition of alternative standards-setting mechanisms developed by the FCC.

The American National Standards Institute (ANSI), a nonprofit multi-industry organization, provides a structure for the development of voluntary American national standards generally. There is a multiplicity of organizations involved in the development of telecommunications standards in the United States, primarily as ANSI members.[523] For example, the Exchange Carrier Standards Association (ECSA) sponsors the T1 Committee, which develops numerous public network standards, including those related to ISDN. The Electronic Industries Association (EIA) and the Institute of Electrical and Electronics Engineers, Inc. (IEEE) act as secretariats for ANSI and also publish approved standards of their own. Moreover, the Telecommunications Industry Association (TIA) cooperates with these organizations in standards development, particularly for telecommunications equipment. Both EIA and IEEE are ANSI-accredited and may submit their standards to ANSI for publication as American national standards.

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[522] *See, e.g.*, OMB Circular No. A-119, *Federal Participation in the Development and Use of Voluntary Standards* (Oct. 26, 1982).

[523] *See, e.g.*, *Telecom 2000*, *supra* note 17, at 665-672.

Standards developed in these private forums are adopted through consensus in a pluralistic fashion. Participation in ANSI committees is open to all segments of the telecommunications industry, including foreign service providers, equipment manufacturers, and users. Government representatives may serve on ANSI councils or boards. Results of these deliberations are published and available to all.

As examples of standards activity, T1 subcommittees are building on their earlier narrowband ISDN work in developing advanced broadband transmission standards.[524] The mobile radio industry is studying possible new standards such as TDMA, CDMA and other transmission techniques for new mobile radio services, largely through TIA groups.[525] Public network operators are studying the standardization of operational, administrative, and maintenance function and interconnection of signalling systems.

The government's role in these standards development activities has varied. As large users of services and equipment, federal and state governments have had a prominent role in technology standards discussions from the user's viewpoint.[526] Where international standards are set by treaty organizations (as with CCITT and CCIR) the U.S. is represented by a delegation of federal government officials and telecommunications company representatives, led by the Department of State.[527] The federal government can act as a mediator or "honest broker" to help resolve disputes when the consensus-building process is breaking down. In addition, it can examine or ask the industry or a third party to examine whether current consensus-building processes are open to wide participation, and based on fair and efficient procedures.

As regulators, both federal and state governments have, if necessary, directed industry to develop specific technical standards, resolved particular disputed technical issues, dispute, or specified specific standards for the industry. For example, the FCC has set certain guidelines to ensure that standards promote, rather than impede, important public policies such as the development of competition in telecommunications markets, as it has done with respect to the interconnection of CPE, interexchange services, and enhanced services to local exchange networks. The FCC's leadership in developing standard CPE connectors through its Part 68 process[528] illustrates this active role. In recent years, although the FCC participated in ISDN development primarily in an informal way,[529] it has articulated a need for technical specificity in particular areas, encouraging the industry to find consensus regarding the technical details.[530]

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[524] *See* Stallings, *CCITT Standards Foreshadow Broadband ISDN,* Telecommunications, Mar. 1990, at 29-41.

[525] *See supra* note 430.

[526] Federal agencies involved in standards setting activities include the National Communications System (NCS) which develops nationwide emergency interoperability standards for federal coordination and approval.

[527] *See, e.g.*, Besen and Saloner, *The Economics of Telecommunications Standards,* in *Changing the Rules: Technological Change, International Competition, and Regulation in Communications* 189-191 (R. Crandall and K. Flamm eds. 1989).

Commenters discussing standards development activities in response to the Notice focus on process issues, including whether (a) the standards process is too slow,[531] (b) all participants are treated equitably, and (c) issues may be "falling through the cracks."[532] With respect to the latter issues, USTA and others suggest that the industry requires more coordinated planning among carriers to deal with the technical complexities of advanced telecommunications.[533] Some commenters call for government to actively initiate or adopt particular standards,[534] although others counsel against such a role.[535] PacTel supports an affirmative policy to ensure that uniform standards allow for maximum connectivity between public network users and all other networks and their users.[536] NTCA/OPASTCO recommends that the FCC create a nationwide LEC planning body on the model of the National Exchange Carriers Association (NECA) to develop a comprehensive, overall approach to nationwide infrastructure decisions.[537]

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[528] *See, e.g.*, 47 C.F.R. § 68.500 (1990).

[529] *See, e.g.*, *Integrated Services Digital Networks*, 98 FCC 2d 249, 287 (1984).

[530] For example, the FCC played such a role with respect to ONA development. *See Filing and Review of Open Network Architecture Plans*, 4 FCC Rcd 1, 14 (1988), *recon.* 5 FCC Rcd 3084, *further recon.*, 5 FCC Rcd 3103 (1990).

[531] Many participants in a 1989 National Research Council workshop on standards felt that the standard-setting process is too slow and inhibits innovation. National Research Council, *Crossroads of Information Technology Standards* 2 (1990). Commenters suggest that lack of standards delayed cellular radio and continue to delay ISDN. *See* Comments of Bruce Egan at 5; Comments of Ameritech, App. A at 40.

[532] NASA, for example, characterizes the U.S. standards process as cumbersome and resulting in unnecessary delays. Comments of NASA at 9. *See also* Comments of USTA at 35. Ameritech notes that while the process may sometimes lead to delay, it can achieve firmer conclusions which enjoy wide industry support. Comments of Ameritech, App. A at 39-40. MCI asserts that T1 working group chairmen can arbitrarily influence the consensus process, which can adversely affect different industry segments. Comments of MCI Telecommunications Corp. at 27. *See also* McQuillan, *Setting a Faster Standards-Setting Pace*, Network World, Mar. 11, 1991, at 35.

NYNEX suggests government oversight to ensure broad industry participation. Comments of NYNEX Corp. at 17. IDCMA asserts that greater government oversight may be needed to correct continuing problems. Comments of IDCMA at 26. MCI defines a government role, within the existing framework, to safeguard the interest of the many parties involved, but not force early adoption of standards or prevent any party from having an equal opportunity to present its position. Comments of MCI Telecommunications Corp. at 28-30. USTA recommends that federal policy should encourage those with a legitimate interest to actively participate, rather than engage in obstructionist activities. Comments of USTA at 34-35.

[533] *See* Comments of USTA at 36.

[534] *See, e.g.*, Comments of Ericsson Corp. at 31-32.

[535] *See, e.g.*, Comments of Verilink Corp. at 15; Comments of CBEMA at 13.

Few would question the important role that telecommunications standards have played in shaping highly functional, coordinated, and responsive equipment and service markets in the United States and in the global marketplace. The activities of U.S. standards organizations generally have been impressive, yielding a solid record of achievement that has guided telecommunications industry development and contributed to the formulation of reasonable U.S. positions on telecommunications issues before international standards bodies.

However, we believe that the standards process, and the government's role in that process, must continue to improve to support U.S. infrastructure development effectively. First, the Department of Commerce will continue to work for standards development processes that are reasonable, fair, and open to all.[538] Such procedures recognize the multiplicity of U.S. providers and users that are affected by, and can bring valuable insights to, the standards process. As commenters point out, we recognize that such openness and due process requirements pose tradeoffs for infrastructure development. Although an open process has the potential to gather perspectives and data from more than just a single company, it can result in delays due to the necessary procedures to ensure openness or, conceivably, to strategic behavior for competitive purposes by participants.[539]

Nevertheless, we believe the task of standards-setting is best left to the private sector, without governmental interference. We recognize that there may be rare cases where FCC or NTIA action to expedite the standards process could be justified. This could be necessary in areas, such as the development of interconnection standards, that would require competitors to agree on matters that could directly involve their relationship.

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[536] Comments of PacTel at 32-33.

[537] Comments of NTCA/OPASTCO at 42.

[538] Conversely, foreign standards organizations should allow U.S. companies to participate fully in standards activities, just as we permit foreign companies to participate in our standards making processes.

[539] Of course, there are dangers that standards can be set too early in the development of a technology— that is, standards can impede technological advances if such advances require changes in an accepted standard. No commenter raised this as a concern about the current telecommunications standards process, however.

Such intervention could include mediation among conflicting interests, or a mandate to industry to develop standards by a time certain, leaving the actual development of standards to the private sector.

Any intervention, however, should be limited to cases where there is a specific and clearly identified market failure, and where the consequences of that failure outweigh the risk of a regulatory failure (*i.e.*, forcing the resolution of a standard too early in the development of a technology). In addition, the FCC and NTIA should recognize and be alert to the consequences of standards development for the infrastructure. Both agencies should therefore make a priority of monitoring the progress of standards development.

As a fundamental policy objective, it is important that public networks be able to interconnect and interoperate smoothly. In the first instance, private standards organizations should, through their own initiative, identify systematically and resolve expeditiously issues that affect such interoperability, ultimately refining existing standards and developing new standards when necessary.

An important related activity is the translation of standards that commonly provide numerous technical options into specifications that ensure interoperability in a multi-vendor environment. Implementation agreements and conformance tests of complex standards can clarify existing ambiguities, demonstrate the workability of various options and ensure that products from different vendors can work together.[540] Users can benefit substantially from industry efforts to further refine standards after their initial development. The importance of such efforts has continued to increase with the proliferation of service and equipment vendors.

D. DEVELOPING NETWORK TECHNOLOGIES: GOVERNMENT'S ROLE

Various models could define a role for government in developing network technologies. Historically, U.S. telecommunications development has relied largely on private capital and private initiative, with some regulatory oversight, to build highly-valued and functional networks. In recent years, regulatory policies have promoted competition in equipment and some service markets. Competition, in turn, has stimulated the development of technology and networks, providing an unprecedented range of customer options. Before discussing in Chapter 6 the public benefits of further competition in promoting further telecommunications development, this section will highlight several domestic technology development issues.

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[540] The National Institute of Standards and Technology (NIST) has demonstrated the importance of this activity in its sponsorship of two workshops to develop implementation agreements and tests associated with ISDN and Open Systems Interconnection (OSI) standards.

As a matter of policy, government should encourage regulated entities to invest in telecommunications at a rate that is responsive to both market demand and technical opportunities. This "efficient" investment rate would not allow equipment to be employed after it has become technologically and economically obsolete. Nor would it result in an over-investment in, and over-commitment to, current "mature" technologies, delaying the opportunity to introduce future technologies as they develop. A substantial reform in this area would be for the FCC and state regulators to set depreciation rates for network equipment to reflect these considerations. The goal for a "proper" investment rate should be to encourage a healthy mix of network technologies that can provide services that respond to customer needs.[541]

Some commenters advocate policies to stimulate full deployment of specific technologies, such as public networks that contain only digital switching. In the extreme, such policies call for government to commit our telecommunications infrastructure wholly to a choice among technologies available or anticipated today. Government would encounter several difficulties with this approach. First, market demand generally focuses more on services than technologies. Users are most often concerned about cost and performance capabilities of services, rather than the particular technology or facilities underlying those services. Providers generally market services and freely replace underlying technologies when advantageous, in a manner transparent to users. Even if government policies attempted to focus on the selection of technologies by or for private-sector firms, government would not necessarily make the right choice. Since today's technical advance could be tomorrow's obsolete technology, policies endorsing specific technologies would have to stay apace with technical progress. Because of the deliberate pace of government policy-making, as well as the rapid changes in telecommunications technologies we have outlined above, we question whether such rapid changes in policy could occur.

In allowing an efficient level of public and private network investment, government policies should promote the ability of network operators to choose technologies that meet a wide range of user needs. As we discuss in Chapter 6, rather than mandating investment levels and technology choices, the FCC and the states should encourage further competitive market development. The U.S. experience with competition in the long-distance services and equipment markets illustrates the possibilities. Long distance competition, for example, has accelerated the deployment of fiber optic transmission equipment and digital facilities.[542] Equipment competition has promoted the development of very sophisticated terminal equipment features, competing directly with network-based features such as Centrex. Competition has spawned a large array of private network equipment and multi-functional terminal devices for voice, data and video applications. The aggregate level of telecommunications investment has risen substantially with the growth of competition. Government policies to encourage further competition can stimulate, rather than replace, private sector initiatives to provide the appropriate level and mix of public and private network investments and technologies.

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[541] Depreciation rate decisions involve service issues as well as technology development concerns, not the least of which is the impact of such decisions on service prices. For a further discussion of depreciation issues, see *infra* notes 917-941 and accompanying text.

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[542] *See, e.g.*, Wallace, *MCI says it will accelerate net digitization by 2 years*, Network World, Aug. 27, 1990, at 4.

Chapter 5

U.S. Infrastructure: International Comparisons

I. INTRODUCTION

Perhaps no single subject raised by the Notice has caused a more spirited debate than the state of the U.S. communications infrastructure. Are our telecommunications capabilities currently adequate to serve the needs of U.S. consumers and businesses? As we look into the future, what trends do we see affecting the development of this critical component of national infrastructure? And, in particular, how will our telecommunications infrastructure affect the ability of U.S. workers and businesses to compete in our increasingly global marketplace?

There is general agreement that, historically, the United States has had the "best" telecommunications network in the world, although the criteria used in making this judgment have often gone unstated. As we discuss in this chapter, there is some disagreement as to whether the U.S. network is currently the most advanced in the world. The most vigorous debate in the comments in this proceeding, and elsewhere, has occurred over whether, if present trends in network development continue, the state of the U.S. network will fall "behind" those of other countries.

In this chapter, our analysis uses international comparisons of telecommunications investment and technology deployment to explore these issues.[543] In doing so, we note that such benchmarking necessarily has certain limitations. Because countries have different economic and social characteristics, their telecommunications needs and states of development also differ. Thus, as a starting point, we believe that no single comparison or set of comparisons "proves" that the United States is "gaining" or

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[543] This analysis primarily focuses on telecommunications facilities and technologies in the United States and other large countries, rather than telecommunications services. Meaningful international comparisons of services are difficult, if not impossible, to develop because many countries permit subsidization of their tariffed services, thereby preventing identification of "true" costs and prices, and the diversity of offerings and the nuances of tariff structures substantially hamper such inter-country analysis.

"losing" relative to other countries in telecommunications. Indeed, comparisons of specific quantitative measures cannot, by themselves, conclusively resolve the critical question of whether the United States is meeting its telecommunications policy goals.

Nevertheless, international comparisons can serve as valuable points of reference for evaluating the progress of the United States in developing its national telecommunications infrastructure. If comparisons show that other countries are investing more in telecommunications than the United States, U.S. policymakers and businesses should examine why such investment is occurring and whether conditions argue for similar levels of investment in the United States. For example, the experience of other countries in deploying a specific technology at a rate different than that in the United States should raise questions as to why that is occurring and also permit us to observe the results of such deployment. Finally, to the extent that other countries have well-defined policy goals for telecommunications, comparisons aid in evaluating the way in which those countries are meeting their goals.

In this chapter we develop intercountry comparisons of telecommunications investment, telephone penetration, network usage, deployment of advanced technology, and service quality. The use of cross-sectional[544] and time-series[545] analyses affords comparisons with multiple dimensions. We attempt to address the many variables and difficulties in obtaining data on which to base such comparisons.

Our work in this chapter builds on the efforts of many commenters that address the state of U.S. telecommunications development. Several parties present qualitative or quantitative findings with respect to the status of this country's telecommunications infrastructure relative to other nations. We now turn to these assertions.

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[544] Cross-sectional analysis pertains to a set of data involving observations taken at one point in time. For example, telecommunications investment data could be compared among a number of countries for a recent year.

[545] Time-series analysis involves a set of observations on the values that a variable takes at different points in time. For example, ISDN deployment could be compared for the years 1985-1989 for a particular country. This type of analysis can, of course, be combined with cross-sectional data. For example, a comparative time series would track data for two or more countries over a multi-year period, either serially or nonconsecutively.

II. THE RECORD

A. OVERVIEW

One group of commenters believes that the United States' historical lead in telecommunications has eroded sharply in recent years.[546] Management Education Services Associates (MESA), a consulting firm employed by the BOCs and other LECs, argues that while this country has been a leader in many aspects of public telecommunications, the U.S. "lead has narrowed or disappeared altogether in a number of critical areas."[547] MESA warns that "[t]hose who believe that the US public network is the most advanced in the world, and will remain so, have not considered all the facts," a theme also endorsed by Darby Associates (Darby), employed by USTA.[548]

Another group of commenters[549] attacks the contention that the United States is somehow falling short in comparisons with other countries' telecommunications capabilities, claiming that it is "little more than a transparent fiction, based upon a fundamental misuse of data and analysis."[550] Economics and Technology, Inc. (ETI), a consulting firm employed by ICA and CFA, contends that in actuality, "[v]irtually every available indicator of the performance and usage of public telecommunications networks shows that the [United States] remains far ahead of its strategic competitor nations."[551] In short, ETI claims that "the US telecommunications infrastructure is simply in great shape today."[552]

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[546] *See, e.g,* Joint Submission of Bellcore at 5-6; Comments of Bell Atlantic at 4; Comments of BellSouth Corp. at 13-17, App. A; Comments of PacTel at 16; Comments of DEC at 8-10; Comments of ITN at 3-5; Comments of University of Pittsburgh at 1; Comments of USTA at 16-17; Joint Reply Submission of Bellcore at 6-7; Reply Comments of USTA at 15-24.

[547] *See MESA Study, supra* note 446, at 1.

[548] *Id.* at 2. Among others in this proceeding who support this thesis, Darby has undertaken a relatively extensive analysis of the subject, concluding that apparently "our trading partners and competitors in the world's marketplaces are investing in telecommunications infrastructures at rates exceeding those . . . in the U.S. data." *See* Darby Associates, *Capital Formation in U.S. Telecommunications* at 20-21 (*Darby Study*) (submitted as Attach. 1 to Reply Comments of USTA).

[549] *See* Comments of ICA/CFA at 3, 5-7; Comments of ADAPSO at 9; Comments of AT&T at 9-13; Comments of Cox Enterprises, Inc. at 7; Comments of IDCMA at 12-13; Comments of McCaw at 4-5; Comments of MCI Telecommunications Corp. at 2-9; Comments of TCI at 16-17; Comments of United Telecommunications, Inc. at 4-6; Reply Comments of AHTUC at 5-6, 10-12; Reply Comments of NASUCA at 20, 22.

[550] Economics and Technology, Inc., *The Telecommunications Infrastructure in Perspective* (*ETI Study*) (submitted as Attach. A to Comments of ICA/CFA).

[551] *Id.* at 4.

[552] *Id.* at 5.

In reply comments, MESA criticizes ETI for focusing on the wrong data. MESA contends that ETI's failure to use data more recent than 1987 "means that dramatic trends and developments are not factored into the analysis."[553] Moreover, MESA argues that ETI's omission of any projections in its study ignores the "key issue" of the future standing of the U.S. public infrastructure.[554] It stresses that the perception that other countries are "struggling to catch up" with the United States "simply does not square with the facts."[555]

In supplemental comments, ETI contends that neither MESA nor Darby sufficiently emphasizes the importance of capital budgeting criteria and engineering economics in telecommunications investment decisions.[556] Moreover, ETI states, foreign countries must make greater investments in telecommunications than the U.S. industry because of fewer realized scale economies.[557] ETI also states that potential services—not technologies or capabilities—should be the focus of the comparisons, and that the relative maturity of the U.S. market should dissuade LECs from pursuing investment as vigorously as in other nations.[558] Finally, ETI believes that the "market policy issue [*i.e.*, recognition of intercountry differences in market structure and the level of competition] may be the most important key in the infrastructure debate."[559]

Recognizing the limitations of international comparisons mentioned earlier, the following sections address the relevant major claims in this debate, focusing primarily on the positions advanced by MESA and ETI.[560] Specifically, we examine U.S. and other countries' investment levels per access line, telephone penetration rates, network usage, comparative switching and fiber transmission capabilities, deployment of ISDN and SS7, and service quality.

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[553] Management Education Services Assoc., Inc., *Analysis of Errors in Economics and Technology, Inc.'s "The Telecommunications Infrastructure in Perspective"* at 1 (*MESA Rebuttal*) (submitted as Attach. 4 to Joint Reply Submission of Bellcore).

[554] *Id.* at 12.

[555] *Id.* at 4.

[556] *See* Economics and Technology, Inc., *A Review of the Telecommunications Infrastructure Modernization Debate* at 2-3 (*ETI Supplemental Comments*) (submitted as Attach. A to Supplemental Comments of ICA).

[557] *Id.* ETI argues that these parties fail to take into account the constraining effect on new investment in the United States because of capital costs that are higher than in other countries. *Id.*

[558] *Id.* at 4-5.

[559] *Id.* at 5-7.

[560] We examine the claims of these parties for several reasons. First, MESA and ETI themselves focus on international infrastructure comparisons to a greater extent than any other party. Secondly, other commenters in many instances draw upon the same data sources as those used by MESA and ETI; indeed, some even rely upon study results developed by them. *See, e.g.*, Comments of AHTUC at 6-17; Comments of AT&T at 9-13; Comments of MCI Telecommunications Corp. at 5-9. This, of course, does not preclude our own reliance on any source that assists us in our assessment of the U.S. infrastructure.

B. INVESTMENT LEVELS PER ACCESS LINE: POSITIONS OF THE PARTIES

MESA presents data regarding public network investment per access line that show the United States' position to be deteriorating relative to several other countries.[561] MESA's capital investment computations for the United States include only the BOCs and certain IXCs.[562] For example, in 1984, MESA ranked this country (with $193 invested per access line) ahead of Japan ($176), Canada ($152), France ($146), and the United Kingdom ($98).[563] By 1989 the United States—as defined by MESA—was in fourth place ($184 per line) behind Japan ($294), Canada ($252), and the United Kingdom ($252), while leading only France ($181) from the original comparisons.[564] Among the six other countries for which data were provided for the year 1989, the United States trailed five of them.[565] Only two nations among the eleven experienced a declining investment/access line ratio during the 1984-89 period: the United States and Singapore.[566]

ETI states that on a comparable basis, other major countries are investing about the same, or less, per access line than U.S telephone companies.[567] ETI argues that there are a number of errors in MESA's analyses and criticizes MESA as lacking meaningful documentation that would permit an independent check on its calculations.[568] ETI also notes that MESA's investment figures include outlays for CPE in its figures for foreign countries, which represents a type of investment that BOCs are "not required to make;" MESA's use of such figures raises questions about whether MESA's data for the U.S. and foreign companies are comparable.[569] Moreover, ETI contends that exclusion of non-BOC statistics from the U.S. figures also introduces distortions because, for example, rural LECs generally spend more per access line than do the BOCs.[570]

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[561] MESA converts the statistics for foreign countries to US dollars by applying the relevant average annual exchange rates. Sources for these data include "company publications, documents, responses to private questionnaires and contacts unless otherwise noted." *See MESA Study, supra* note 446, at 11, Table 3.

[562] Besides the BOCs, MESA's investment analysis apparently includes data for interexchange companies such as AT&T, MCI, US Sprint, Allnet, and Litel. *See id.* at 11, Table 3, note 5, App. A at 2-3. For other analyses, the number and identity of the companies included frequently differ based on the availability of data, particularly in the case of U.S. firms; the total number of U.S. firms represented in the study equaled 52 (47 LECs and 5 IXCs). *See id.*, App. A at 2-3.

[563] *Id.*

[564] *Id.*

[565] *Id.* The countries are located in either Europe or the Pacific Basin and include Switzerland ($440), New Zealand ($354), Germany ($339), Taiwan ($254), Australia ($246), and Singapore ($107).

[566] *Id.*

[567] *ETI Study, supra* note 550, at 22.

Another perceived shortcoming centers on exchange rate adjustments. Describing MESA's methodological basis as "unclear," ETI uses a currency comparison methodology called "purchasing power parities" (PPPs), which, it says, accounts for both exchange rate changes and trade flow considerations. More specifically, PPPs represent the number of currency units (such as dollars) required to buy goods and services in one country that is equivalent to what can be bought with one unit of the currency of the base country (*e.g.*, the United States). Applying PPP adjustments to MESA's figures, ETI says that the U.S. ranking in 1987 in investment per line rises from sixth behind France, Germany, the United Kingdom, Japan, and Singapore to second, trailing only Germany.[571]

In addition, ETI argues that MESA's calculations reflect a misperception of the true relationship between public and private networks. According to ETI, rather than substitutes, these networks tend to complement each other. When spending on such "private network" facilities as "competitive [non-LEC-provided] terminal equipment" and local area networks is properly added to investment by the telephone companies, ETI says that the total annual telecommunications infrastructure investment in the United States in 1988 exceeded $300 per access line; this figure represents an amount much greater than the levels attributed to other countries.[572]

MESA, in turn, responds that ETI's adjustments distort the investment comparisons, and that the "gaps" that are unfavorable to the United States would actually increase if all necessary adjustments were made.[573] MESA cites survey findings that CPE averages only 8.4 to 17 percent of common carrier capital budgets in various countries, and 3.45 percent in the United States. Therefore, it concludes, removing CPE amounts from the investment figures would "not change the results" of its original analysis.[574]

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[568] ETI also asserts that "uniform national data published by neutral organizations" including the International Telecommunication Union (ITU) and the Organisation for Economic Co-Operation and Development (OECD) are basically consistent with each other, but do not reconcile with MESA's calculations. *Id.*

[569] *Id.*

[570] *Id.* at 23.

[571] *Id.* at 22, 25-27.

[572] *Id.* at 5, 35-36.

MESA identifies other factors that, it says, would have a greater impact on the relative spending statistics. In a number of countries, it states, labor costs associated with network modernization are expensed; in the United States, they are capitalized, with the recent exception of station connections.[575] In Japan, such capitalization would boost investment totals by more than 20 percent per year. The U.S investment figures already include labor costs that equaled 28.7 percent of LECs' capital budgets in 1989.[576]

MESA also dismisses PPP rates as "artificial" and not properly developed in the ETI analysis. It argues that foreign carriers receive greater modernization impact per dollar of investment because of relatively high telecommunications equipment and labor costs in the United States.[577] Darby contends that PPPs are inferior because they represent only general purchasing-power differences among countries and, thus, are too broad-based for decisive applicability to telecommunications.[578]

C. DISCUSSION

In examining the analyses submitted by MESA and ETI, we are struck by their fundamentally different approaches. Concerning infrastructure investment specifically, MESA focuses on the "public network," defined as facilities that are provided primarily by the BOCs and certain interexchange carriers, while ETI emphasizes the complementarity of the public network and certain private networks. Moreover, we agree with certain of the criticisms leveled by each of these parties at the analyses submitted by the other regarding investment per access line.

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[573] *MESA Rebuttal, supra* note 553, at 5.

[574] *Id.* at 5, 6.

[575] Station connections include the segment of inside wiring from a demarcation point on the customer's side of the "protector" (a device designed to safeguard against electrical surges) to the CPE. Historically, costs associated with station connections were capitalized for accounting purposes. In *Expensing of Inside Wiring*, 85 FCC 2d 818 (1981), the FCC ruled that these costs are primarily labor-intensive in nature and should be directly expensed to ensure that the agency's "cost causation" principles are followed. The Commission directed that inside wiring costs capitalized in Account 232 ("Station connections—inside wiring") through October 1, 1981, and as allowed during a four-year phase-in period, be amortized over a period not to exceed ten years. By September 30, 1994, all embedded inside wiring costs must achieve a zero net investment level (*i.e.*, be completely amortized). Inside wiring costs incurred subsequent to October 1, 1981 and not capitalized during the phase-in interval, are expensed.

[576] *MESA Rebuttal, supra* note 553, at 6.

[577] *Id.* at 7.

[578] *Darby Study, supra* note 548, at 23 n.51.

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For example, MESA's decision not to incorporate data for the independent telephone companies represents a somewhat puzzling omission. There are some indications that ETI may be right in asserting that the independents spend more per access line than the BOCs. For example, using "total plant added" per access line as a unit of comparison, the independents' expenditures were more than one-third higher than the BOC total in 1989.[579] In addition, the independents' share of total LEC (*i.e.*, BOCs plus independents) network expansion budgets averaged 28.5 percent during 1988-1990 although their share of total access lines apparently averaged some five percentage points less.[580] Moreover, there are indications that the greater investment has resulted in a faster rate of modernization in at least some independents' networks.[581] MESA's analysis also omits such segments of the infrastructure in this country as private networks, mobile telephony, suppliers of microwave and satellite transmission capacity, and alternative local service providers.[582]

While we agree with MESA that collecting data on the latter types of providers poses problems, it is difficult to evaluate its assessment that were such data included in its analysis, the "results would not significantly alter our conclusions about relative capacities of the telecommunications infrastructure of the countries studied."[583] Without the data, of course, no definitive conclusion is possible. However, there have been recent estimates that about one-fourth to one-third of all spending on capital equipment and telephones in the United States is being undertaken by those other than regulated carriers. Much of this investment presumably is for CPE,[584] which is unregulated in the United States but treated as part of public network investment in many other countries. ETI correctly notes that MESA does not adjust for the difference in U.S. and other countries' regulatory treatment of CPE. Without endorsing any particular estimates, we note that, because of the widespread availability of advanced CPE in the United States, and long-standing (relative to the rest of the world) policy permitting users to interconnect CPE with either carrier-provided leased lines or purely private transmission facilities to construct private networks, it is likely such networks are a substantially more important component of infrastructure in the United States than they are in other countries.[585] Nonetheless, even those that point to the robustness of private networks in this country state that "[t]rue public network expenditures in the [United States] far exceed private network investments."[586]

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[579] In 1989, the independents that reported to the FCC spent $189.61 per access line for plant additions, which was 37.4 percent higher than the corresponding figure of $138.03 for the BOCs. *See* Federal Communications Commission, *Statistics of Communications Common Carriers*, Tables 2.7 and 2.10 (1989/90 ed.) (*1990 Common Carrier Statistics*).

[580] *See Domestic Review and Forecast*, Telephony, Dec. 17, 1990, at 36 (using data developed by Telephony/Market Research); *Spending strategies for the 1990s*, Telephony, Dec. 18, 1989, at 34. In 1988 and 1989, the independents' share of the industry's total access lines equaled 22.3 percent and 23.2 percent; no data were available for 1990. *See 1990 Common Carrier Statistics*, *supra* note 579, Table 2.10; Federal Communications Commission, *Statistics of Communications Common Carriers*, Table 2.10 (1988/89 ed.) (*1989 Common Carrier Statistics*); USTA, *Phone Facts '90*; USTA, *Phone Facts '89*.

[581] *See, e.g.*, Comments of Technology Futures, Inc. at 20 (a significant difference between the BOCs and the independent LECs is that some of the independents have tended to deploy digital switching faster). *See also Doing the Right Thing*, Telephony, Mar. 25, 1991, at 36 (Centel CEO John Frazee believes that rural areas and small towns in the United States—where independents have numerous local exchange areas—have more modern communications technology today than many urban communities).

[582] MESA recognizes the existence of these omissions. *MESA Study*, *supra* note 446, App. A at 3.

[583] *Id.* MESA provides little further explanation for its conclusion in this regard.

On the other hand, we accept MESA's criticism that the ETI methodology overlooks a potentially important distinction, namely, the differing treatment of labor costs associated with infrastructure investment. Adjusting foreign figures (which reportedly reflect an expensing of labor costs in at least certain instances) to compensate for the American practice of capitalizing labor costs could result in substantial revisions. We address these and other issues in the analysis that follows.

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[584] For these purposes, we define CPE as telephone handsets, key systems, modems, PBXs, and other customer terminal equipment.

[585] In mid-1988, one researcher attributed one out of three dollars of U.S. telecommunication capital expenditures to nonregulated entities. Comments of NGA, Attach. 1 at 3 (remarks of Robert Crandall, Brookings Institution). With the benefit of additional data, Dr. Crandall estimates that spending for government and business customers on private systems equaled 29 percent of total telecommunication capital expenditures for the full-year 1988. He derives this percentage by comparing Bureau of Economic Analysis (Commerce Department) figures on total capital expenditures on "telephone and telegraph" with FCC data on such spending by regulated telephone and telegraph carriers. In turn, the private systems category consists of private network equipment ($4.7 billion in 1988; 42.3 percent of the category), inside wiring charged directly to business and government customers ($2.7 billion; 24.3 percent), nonresidential CPE ($1.9 billion; 17.1 percent), and large PBXs $1.8 billion; 16.2 percent). R. Crandall, *After the Break-up: U.S. Telecommunications in a More Competitive Era* 45-47 (1991)1 (*Crandall*). Overall, he estimates that "nearly 25 percent of all telecommunications net capital stock is in the hands of someone other than a telephone company and that about 19 percent of it is in private business networks or communications systems." *Id.* at 48.

[586] *ETI Study, supra* note 550, at 35-36.

III. THE NTIA COMPARISONS

A. BACKGROUND

In examining the subjects of this debate, we seek to ascertain, to the extent possible, the status of U.S. telecommunications infrastructure. As noted above, NTIA believes that international comparisons, while not the sole determining factor in how U.S. telecommunications capabilities should evolve, can provide useful information and points of reference for evaluating the present and projected U.S. infrastructure. Such comparisons can permit U.S. policymakers to learn from the experiences of others.

Given the spirited nature of the debate on telecommunications investment as reflected in the record, NTIA is under no illusion that a definitive set of comparative investment figures can be derived. Rather, we seek to gain perspective on U.S. progress in this area, ranking the United States in a broad sense relative to our major trading partners and competitors.

Ideally, infrastructure comparisons would include, at least as a starting point, a nation's total investment in public and private telecommunications capabilities. A lack of data—both here and in other countries—does not permit such comprehensive evaluations.[587] We regard each of these types of infrastructure as important. Private networks presently complement the public network by affording large users specialized features at low cost. However, public networks are crucial to the infrastructure because they are available to all telecommunications users, including small businesses, social service institutions, and ordinary Americans. As discussed in Chapter 2, much of our attention in this report accordingly is focused on the U.S. public network. Therefore, we will use public networks as the basis of our comparisons, recognizing both the relevance of these figures for policymaking and their limited nature.[588]

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[587] For the United States, there exists an approximation of the combined public and private telecommunications infrastructure in a recent year. Crandall estimates that in 1988, the U.S. telecommunications net capital stock totaled $38.6 billion. According to his analysis, regulated carriers accounted for 63.2 percent; private networks, 12.2 percent; CPE and large PBXs, 12.6 percent; and inside wiring directly charged, 11.7 percent. *See Crandall, After the Breakup: U.S. Telecommunications in a More Competitive Era* 45-47 (1991), at 47-48. According to Gilder, there are approximately 700,000 private networks in the United States. *See* Gilder, *Into the Telecosm*, Harv. Bus. Rev., March/April 1991, at 160.

We have found no comparable estimates for foreign countries. We are aware that the role of private networks seems to be growing in at least some of these nations. For example, private networks in Western Europe built around dedicated circuits currently number some 14,000 and carry an increasing share of traffic, especially data communications. *See* OECD, *Communications Outlook 1990* 32-33 (1990). Leased lines obtained from carriers will likely become even more popular among the types of European private networks that develop in the future as "single-source shopping" becomes increasingly attractive in a more unified Europe. *See Private Networking*, Communications Week, Dec. 24, 1990, at 22. However, data on private networks that are not based on the public network are generally unavailable.

We use data collected by the International Telecommunication Union (ITU) and the Organisation for Economic Co-Operation and Development (OECD). These entities represent, for our purposes, relatively "neutral" and apparently "uniform" sources of data that would help us develop meaningful comparisons. Regrettably, the international statistics are not as recent as desirable—in most cases going only through 1989. Still, we view this situation as preferable to a more up-to-date but less consistent or reliable set of numbers from other sources.[589]

Incorporating price-related adjustments into the analysis presents a thorny problem. There is no one "correct" exchange rate basis for our purposes. An approach that has considerable conceptual appeal is the aforementioned PPP, as advocated by ETI. International organizations such as OECD and EUROSTAT, and the U.S. Department of Labor's Bureau of Labor Statistics, currently use the PPP methodology. In particular, the OECD relies on a form of PPP approach to develop price data that can be used for performance evaluations of telecommunications against other sectors of the economy.[590] The method has some shortcomings in practice, however, including difficulties in harmonizing the benchmark "basket" of communications prices and services over time and between countries, as well as the concomitant need for more recent data. We also recognize that although the basket is sector-specific, the inclusion of postal service and other expenses does not sufficiently narrow the focus to the desired basket of "telecommunications capital goods" needed for our infrastructure modernization comparisons.[591]

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[588] As ETI notes, most private networks in this country appear to be "constructed out of 'public network' elements." *ETI Study, supra* note 550, at 31. For example, the telecommunications facilities of General Motors—one of the nation's largest private users—is reportedly "'99 percent' public network based." *See* R. Entman, *State Telecommunications Regulation: Toward Policy for an Intelligent Telecommunications Infrastructure* 3 (Aspen Institute Communications and Society Forum 1989). ETI states that in the last few years, the modernization activities of the RBOCs and other carriers have resulted in "more and more of the total telecommunications traffic of American businesses [being] carried over the public switched network." *ETI Study, supra* note 550, at 32-33. Indeed, a recent *Wall Street Journal* survey of 363 ICA members indicates that their largest budget growth area in 1990 was anticipated to be private lines obtained from carriers. *See* ICA, *Telecommunications: The Decision Makers* at 24 (1990). Given these occurrences and the apparent preponderance of the world's "private" networks in the United States, our emphasis on comparisons of public networks would not seem to be misplaced.

[589] We note that MESA's investment data only goes through 1989 and even that far only for selected countries. By contrast, MESA includes in its analysis of the relative rates for deployment of particular technologies projections for future periods. We analyze these data *infra*.

[590] OECD, *Performance Indicators for Public Telecommunications Operators* 101 (1990) (*OECD Report*).

[591] *See id.*; *Darby Study, supra* note 548, at 16 n.51.

For comparative cross-sectional analysis involving telecommunications investment, the OECD staff generally uses the PPP approach. However, because of data reliability concerns, it converts the various national currencies into constant U.S. dollars through the use of average exchange rates and price deflators. To avoid the methodological shortcomings of the PPP approach in studies involving time series during the early 1980s, our analysis will make intercountry investment comparisons using deflated average exchange rates.

B. PUBLIC TELECOMMUNICATIONS INVESTMENT

Table 5.1 depicts average annual "public telecommunications"[592] investment per main line[593] for the period 1980-1989 for OECD member countries, plus Singapore. The

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[592] "Public telecommunications investment" as used in this analysis generally includes capital investment expended by public telecommunications providers in each country; outlays for land and buildings are usually excluded. We concur with ITU's view that net investment, while an important statistic, is virtually "impossible" to use in intercountry comparisons because of the widely varying interpretations of depreciation among international telecommunications communities. *See* ITU, *Yearbook of Common Carrier Telecommunications Statistics* (18th ed., Chronological Series 1980-1989) (1991) (*ITU Yearbook*). For this reason, the capital investment figures that appear in this section are gross investment.

The data that we use are collected by the ITU from a variety of sources and generally include telephone, telegram, telex, and data transmission services. *See id.* For the United States, the FCC collects statistics on the BOCs and independent LECs (which represent 52 companies and accounted for 94 percent of the nation's local telephone service revenues, and 93 percent of the access lines in 1988), telegraph carriers, and long distance carriers AT&T and Alascom. *See 1989 Common Carrier Statistics, supra* note 580, at v. As discussed *infra,* we believe that these investment numbers should be supplemented by those for MCI and U.S. Sprint.

[593] As defined by the ITU, the source of the data for this table, a "main line" is a "telephone line connecting the subscriber's terminal equipment to the public switched network and which has a dedicated port in the telephone exchange equipment." *See ITU Yearbook, supra* note 592, at 14. The term is used synonymously with "main station," a statistic collected for many years in the telecommunications industry. A "main line" differs from an "access line" in that it does not include connections, such as trunks or lines, to either PBXs or Centrex. Use of main lines rather than access lines will tend to overstate investment per line calculations, especially in a country where there exists a relatively large PBX base, such as the United States.

We recognize that with the onset of the FCC's access charge program in the early 1980s, data relating to main lines have not been collected on a regular basis in this country. For purposes of its comparisons, OECD has compiled such data annually from a number of different estimates. Although number of access lines is the preferred unit of measure in the United States, main lines continues to be the measure of choice in other countries. So that consistent data collected by an independent neutral body may form the basis of our own comparisons, we incorporate main lines into our analysis. For the United States and the other countries in our study, we turn to data collected by ITU and OECD. During this period, the annual number of access lines in the United States consistently exceeded the corresponding main-line count in the United States. *See also* USTA, *Statistics of the Local Exchange Carriers* 2 (1989); Federal Communications Commission, *Statistics of Communications Common Carriers* for the years 1984-1989 (Table 15 or 2.10). Changes in the FCC's method of collecting data for main lines in the United States may account for an increase in main lines after 1987.

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COUNTRY	AVERAGE ANNUAL INVESTMENT PER MAIN LINE, 1980-1989 (U.S. $)[a]	RANKING
Ireland	419.36	1
Norway	356.23	2
Switzerland	340.00	3
Germany	305.15	4
Austria	302.87	5
Australia	277.70	6
Italy	274.72	7
Japan	243.99	8
Canada	242.28	9
Finland	240.72	10
Spain	239.09	11
France	239.06	12
United States	217.89	13
Portugal	201.83	14
Belgium	186.78	15
Sweden	178.54	16
Singapore	177.42	17
Denmark	165.32	18
United Kingdom	160.58	19
Luxembourg	154.63	20
New Zealand	134.09	21
Netherlands	125.90	22
Iceland	116.87	23
Greece	102.88	24

* Capital investment by public telecommunications operators excluding land and buildings. Unadjusted for differing treatments for labor costs and CPE inclusion.

** OECD members plus Singapore.

(a) Constant 1989 U.S. dollars (adjusted for inflation and exchange rates).

SOURCE: Unpublished OECD data, adapted from *ITU Yearbook of Statistics*, data provided by MCI and US Sprint; *Telephony*, January 10, 1983, at 36; Jan. 13, 1986, at 36; Jan. 9, 1989, at 26 (hereafter, MCI and US Sprint data).

Table 5.1: Average Annual Public Telecommunications Investment* in Selected Countries 1980-1989**

latter was included because it has received considerable publicity about its telecommunications improvements. We selected a several-year period rather than a single year, such as 1989, because the latter may provide misleading signals regarding the state of a given country's infrastructure development.[594] In discussing the importance of the AT&T divestiture to U.S. infrastructure development, several commenters focus on periods after divestiture, *e.g.*, the years 1984-89.[595] We will first examine the period 1980-89, to present a picture of international investment trends over a longer period of time. We then briefly discuss U.S. investment trends in the post-divestiture period.

In preparing Table 5.1, we modified the ITU investment total for the United States. In collecting the original data from the United States and over 175 other countries, the ITU requested statistics on the "various branches of public telecommunications, namely on the telephone, telegram, telex and data transmission services."[596] In most countries, "public telecommunications" corresponds to widely available offerings of providers owned, operated, or directly regulated by government. As a general proposition, public telecommunications operators in Europe and Asia provide the bulk of these services under the control of their national governments, although the regimes in many of these countries are embracing liberalization and, increasingly, privatization policies. In Canada, privately-owned telecommunications providers exist, but both these and government-owned providers typically offer public services subject to some degree of regulation.

In the United States, "public telecommunications" providers in the ITU statistics include the independent LECs, the BOCs, AT&T, Alascom, and international carriers. To this listing we have added MCI and US Sprint, the other two U.S. interexchange carriers besides AT&T that serve all 50 states and the District of Columbia. These three carriers represent about 90 percent of the U.S. interstate long distance market.[597] We thus believe it is appropriate to include MCI and Sprint investment in our comparisons.[598]

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[594] For example, Ireland spent $238.43 (1989 constant dollars) in 1989 but averaged $419.36, for the 1980-1989 interval (hereafter, "the interval" or "the period" unless otherwise indicated). The method for calculating 1989 constant dollars, which includes both exchange rate and inflation adjustments is outlined in letter from Dr. Tim Kelly, OECD, to NTIA (Aug. 21, 1991).

[595] *See, e.g.*, Comments of IDCMA at 12; Comments of NATA at 8; Comments of D.C. PSC at 10-11; Comments of TIA at 6; Reply Comments of AT&T at 13-14; Reply Comments of MCI Telecommunications Corp. at 13. *See also, e.g.*, Comments of Ameritech at 64, App. A at 32-33; Comments of Bell Atlantic at 2-14; Comments of BellSouth Corp., App. E at 1; Comments of NYNEX Corp. at 90-93; Comments of PacTel at 38; Comments of Southwestern Bell Corp. at 44-45; Comments of US West at 20; Comments of Citizens at 2, 17; Comments of Ericsson Corp. at 47; Comments of USTA at 5.

[596] *ITU Yearbook*, *supra* note 592, at 13.

Table 5.1 ranks the United States thirteenth out of 24 nations. The U.S. outlay ($217.89) totals significantly less than Ireland ($419.36) and it is also less than the simple arithmetic mean for the group ($217.89 vs. $224.45). Table 5.2 distinguishes those expenditures that are targeted for plant modernization from those devoted to network expansion. This distinction is important conceptually because it recognizes different motivations for infrastructure outlays, thereby reflecting the level of development in a given country. For example, as we discuss below, the United States has already attained a relatively high telephone penetration rate, so one would expect a greater concentration on modernization than expansion. Useful comparisons could then be made with other nations at a similar stage of development.[599]

As shown in Table 5.2, we estimate investment for network expansion by multiplying growth in main lines experienced during 1980-1989 by an average (1989) cost of $1500 per new line.[600] Subtracting this amount from the cumulative public telecommunications investment total for the period will yield a proxy figure for infrastructure modernization.[601] Table 5.2 indicates that a wide divergence in modernization outlays existed among the 24 countries during the period. Ranked by proportion of investment for modernization, the United States trails only Switzerland with 86.6 percent.

A sharper focus on the infrastructure issue can be gained by comparing the investment per main line and investment in modernization for the United States and other members of the so-called "Group of Seven", the nations with the highest Gross National Products (GNP): Canada, France, Germany,[602] Italy, Japan, and the United Kingdom (in alphabetical order). The seven also reportedly plan to spend more on telecommunications than any other nation in 1991.[603] Table 5.3 compares average annual investment per main line of the United States and these other countries. In this listing, a subset of Table 5.1, the United States ranks sixth. The median (Canada's $242.28) and the simple mean ($240.52) for this grouping both surpassed the U.S. figure.

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[597] *See* Federal Communications Commission, *Long Distance Market Shares: Fourth Quarter, 1990* Table 4 (Mar. 22, 1990).

[598] This is not to suggest that these are the only additional entities that should be brought into our analyses. Indeed, as we discuss in Chapter 2 and *infra*, there are other facilities-based providers that can be properly included, such as the other interexchange carriers, CPE providers, cellular and mobile telephony, alternative local service providers, VANs and point-to-point cable television systems. Although we have not included data on such providers in our analysis, because of the difficulty in obtaining these statistics, we believe that further data should be collected on these companies, as discussed in Appendix D.

[599] We attempt such comparisons *infra*.

[600] OECD staff regard this figure as a "rule of thumb" derived by averaging costs from several sources.

[601] We base this approach on work performed by the OECD's Science, Technology and Industry Directorate, Committee on Computer and Communications Policy, to overcome existing data deficiencies in this regard. OECD Secretariat, *Convergence Between Communications Technologies: A Policy Review*, at 55-58 (1991) and conversations between OECD and NTIA staff.

This formulation has no variable for plant replacement in order to avoid intractability problems caused by a lack of data.

We previously demonstrated in Table 5.2 that with one exception, the United States directed a substantially higher proportion of its telecommunications investment to modernization applications than any other country, including the six other major countries, during the 1980s. Table 5.4 also shows that the seven major nations emphasize, albeit in varying degrees, the importance of investment in modernization. Six of the seven, on average, expended at least two-thirds of their total public telecommunications investments on plant modernization projects during the ten-year period, and the seventh (the United Kingdom) exceeded 60 percent for the same interval.

In turn, we create a composite measure by calculating each country's average expenditure per main line devoted to modernization. Table 5.5 presents the results of such a compilation for the seven countries. Using this criterion, Germany's telecommunications modernization investment per line leads among the seven countries, with the United States ranking fourth.

As noted in Table 5.5, these numbers have not been adjusted for differences among countries in the regulatory treatment of CPE and accounting treatment of labor costs associated with network modernization. The differences may be important for purposes of our comparisons. During the 1980s, no country featured a more liberalized CPE policy than the United States. Because end users, and not public telecommunications providers, purchased most of the CPE in the United States during much of this period, the statistics may substantially understate U.S. investment figures compared to countries in which the public telecommunications providers invest in CPE. Of course, practices in other countries vary substantially.

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[602] In this context and throughout the report except where specifically stated otherwise, we use "Germany" to refer to West Germany. Thus, our calculations do not include statistics for East Germany except where specifically noted.

[603] In order, the top spenders in 1991 are estimated to be the United States, Germany, Japan, Italy, France, the United Kingdom, and Canada. The telecommunications expenditures for the seven ranges from $24.1 billion to $3.8 billion. *See* Telephony, Jan. 7, 1991, at 24.

ERRATUM

Please insert this page in place of Table 5.2 on page 157.

COUNTRY	TOTAL PERIOD TELECOM. INVESTMENT (US $M)[a]	GROWTH IN MAIN LINES EXPANSION (000)	INVESTMENT IN NETWORK EXPANSION (%)[b]	INVESTMENT IN MODERNIZATION (%) RANK[c]	
Switzerland	11,185	946	12.7	87.3	1
United States	217,509	19,398[d]	13.4	86.6	2
Sweden	9,364	896	14.4	85.6	3
Germany	76,057	7,865	15.5	84.5	4
Japan	107,251	11,335	15.9	84.1	5
Austria	8,090	912	16.9	83.1	6
Canada	28,244	3,941	20.9	79.1	7
Denmark	4,184	622	22.3	77.7	8
Norway	5,778	873	22.7	77.3	9
Ireland	2,693	420	23.4	76.6	10
Finland	5,181	842	24.4	75.6	11
Australia	16,964	2,850	25.2	74.8	12
Italy	46,785	8,249	26.5	73.5	13
Luxembourg	236	44	27.9	72.1	14
New Zealand	1,742	349	30.0	70.0	15
Spain	22,314	4,568	30.7	69.3	16
France	51,002	11,044	32.5	67.5	17
United Kingdom	33,586	7,667	34.2	65.8	18
Belgium	5,603	1,285	34.4	65.6	19
Netherlands	7,276	1,799	37.1	62.9	20
Iceland	119	37	46.8	53.2	21
Portugal	2,947	1,046	53.2	46.8	22
Singapore	1,278	458	53.8	46.2	23
Greece	2,953	1,516	77.0	23.0	24

* Capital investment by public telecom operators excluding land and buildings. Unadjusted for differing treatments for labor costs and CPE inclusion.

** OECD members plus Singapore.

(a) Constant 1989 U.S. dollars (adjusted for inflation and exchange rates).

(b) Assumes an average cost of US $1500 per new line (1989). Percentages computed using unrounded numbers.

(c) Assumes cost of network modernization = total investment - cost of network expansion.

(d) An increase in U.S. main lines for 1988 may be due in part to changes adopted that year in the FCC's method of collecting data in this area.

SOURCE: OECD, adapted from *ITU Yearbook of Statistics*, MCI and US Sprint data.

Table 5.2: Public Telecommunications Investment*
Comparative Percentages Devoted to Network Modernization
in Selected Countries 1980-1989**

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very limited time frame rather than what is needed: numbers reported by each specific country for the full 1980-1989 period. Accordingly, our adjustments must be regarded as rough-hewn and very approximate.[604]

COUNTRY	AVERAGE ANNUAL INVESTMENT PER MAIN LINE (U.S. $)[(a)]	RANKING
Germany	305.15	1
Italy	274.72	2
Japan	243.99	3
Canada	242.28	4
France	239.06	5
United States	217.89	6
United Kingdom	160.58	7

* Capital investment by public telecom operators excluding land and buildings. Unadjusted for differing treatments for labor costs and CPE inclusion.

** These countries represent the seven largest among all OECD members plus Singapore based on the most recent GNP or GDP data available.

(a) Constant 1989 U.S. dollars (adjusted for inflation and exchange rates).

SOURCE: Unpublished OECD data, adapted from *ITU Yearbook of Statistics*, MCI and US Sprint data.

Table 5.3: Average Annual Public Telecommunications Investment*
The United States and Other Large Countries 1980-1989**

Given this caveat, we attempt to make the investment figures of Table 5.5 more comparable by reducing the foreign investment averages by 15 percent and the United

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[604] Ideally, our analysis would include all investment in CPE on an annual basis for the countries in the study. The limited data that we have obtained suggests that the CPE market is substantial and growing. For example, according to the NATA, U.S. business and government users purchased an estimated $20 billion of CPE in 1990, representing a 53.9 percent increase over 1987. During that period, PBX and key system sales actually declined, from $3.1 billion in 1987 to $2.9 billion in 1990. However, data equipment, facsimile terminals, and voice processing experienced tremendous growth, more than doubling its value to $15 billion in 1990. The U.S. consumer (residential) CPE market, primarily corded and cordless telephones and answering machines, grew from $2.3 billion in 1987 to $3.2 billion three years later. *See* NATA, *Telecommunications Market Review and Forecast* 6-7 (1991) (*NATA Market Forecast*).

States figure by 3 percent to adjust for the CPE differential. These numbers represent points in ranges whose extremes reflect statistics compiled from a variety of sources.[605] Table 5.6 reflects these adjustments for CPE. Deflating the U.S. total by 3 percent and the others by 15 percent yields a new ranking, with the United States in second place.

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[605] The 15 percent is an estimate imputed from the results of three recent studies of CPE as a percent of total telecommunications spending. In one study, Arthur D. Little, Inc., (ADL) estimated that PBXs and key systems (8.9 percent) added to other CPE (9.3 percent) equals 18.2 percent of total telecommunications equipment expenditures worldwide in 1989. *See Where is the Money Going?*, Telephone Engineer and Management, Jan. 15, 1990, at 47-48.

A survey of 1988 and 1989 capital investment plans of 14 major Asian and European countries by Czatdana Inan and Telephony's Market Research Department determined that reported CPE investment averaged 8.4 percent of their total spending. *See MESA Rebuttal, supra* note 553, at 5. ETI submitted data from a study by Telecommunications Research Centre that shows the CPE/PABX proportion of total capital expenditures by the "monopoly PTOs" in France, Germany, the U.K., and Japan to range from 15.0 to 19.0 percent. *See ETI Study, supra* note 550, Data App. at 9.

The ADL study focuses on total (*i.e.*, public and private) equipment purchases; because the survey results relied on by MESA and the statistics relied on by ETI are closer to meeting our need for data pertaining to *public* telecommunications investment by our major competitors, we tend to give them greater weight. However, because the description and documentation provided by both MESA and ETI for their claims are quite sparse, it is difficult to choose between the two.

We recognize the ambiguity caused by the aggregated survey results since Japan, France, Italy, and the U.K. represent only four of 14 respondents; the ETI percentages are attributed to specific countries. On the other hand, the latter appear to be estimates for which we have no methodology to evaluate. The statistics are for different years, 1988-1989 (MESA) and 1986 (ETI), and the lower proportion for 1986 may reflect new realities. In addition, the survey calculation includes land and buildings; for purposes of our analysis, the category would be excluded, likely boosting the percentage by some small amount. Given these ambiguities, we select 15 percent from within this range, noting that the ETI numbers cited here may not include some types of CPE in the excluded study categories, "data switching," "mobile communs.," and "other" equipment. *Id.* This weighting does not substantially differ from that of Darby, which, however, bases its choice of 17 percent only on Arthur D. Little estimates. *See Darby Study, supra* note 548, at 17-18.

The 3 percent for U.S. public telecom spending represents another number selected from within a range. The upper end of the range is 3.5 percent, computed by Telephony's Market Research Department and representing all spending on CPE during 1989 by the BOCs and the 18 largest independents. When the data are disaggregated, the Bell companies registered 3.1 percent while the independents equaled 5.3 percent. *See $24 billion spells mostly sunny skies for the U.S. telecom industry*, Telephony, Jan. 9, 1989, Figures 1 and 2.

At the low end, FCC data show that for all reporting LECs (*i.e.*, 52 companies accounting for 94 percent of the nation's telephone service), AT&T, and Alascom, the CPE proportion totaled 2.2 percent in 1988. *See 1989 Common Carrier Statistics, supra* note 580, Table 2.7. USTA calculated the same CPE percentage in 1987 for 628 LECs (including the BOCs), but only counted station apparatus and large PBXs. USTA, *Telephone Statistics 1988*, at 19.

Comparison of the FCC and USTA CPE categories, coupled with the likelihood that the percentage was higher during the early 1980s when the BOCs still rented a substantial amount of CPE to subscribers, suggests that the figure should be higher than 2.0 percent. On the other hand, these statistics also indicate that the *Telephony* percentage may be overstated as a result of averaging the data for only 18 independents. Considering these factors, we have decided to use 3.0 percent as a reasonable estimate. This percentage is similar to Darby's 3.5 percent, which is based on a survey figure cited by MESA. *See MESA Rebuttal, supra* note 553, at 5-6; *Darby Study, supra* note 548, at 17-18.

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A second potential area of adjustment concerns differing accounting treatments of labor costs among countries. With the exception of station connections, U.S. firms during the 1980s generally capitalized the portion of labor costs associated with their networks.[606]

COUNTRY	TOTAL PERIOD TELECOM. INVESTMENT (U.S. $M)[a]	GROWTH IN MAIN LINES EXPANSION (000)	INVESTMENT IN NETWORK EXPANSION (%)[b]	INVESTMENT IN MODERNIZATION (%) Rank[c]	
United States	192,058	16,181[d]	12.6	87.4	1
Japan	90,560	10,012	16.6	83.4	2
Germany	67,763	7,544	16.7	83.3	3
Canada	20,236	3,301	24.5	75.5	4
Italy	38,052	7,075	27.9	72.1	5
France	46,648	9,929	31.9	68.1	6
United Kingdom	25,932	6,715	38.8	61.2	7

* Capital investment by public telecom operators excluding land and buildings. Unadjusted for differing treatments for labor costs and CPE inclusion.

** These countries represent the seven largest among all OECD members plus Singapore based on the most recent GNP or GDP data available.

(a) Constant 1987 U.S. dollars (adjusted for inflation and exchange rates).

(b) Assumes an average cost of US $1500 per new line (1989). Percentages computed using unrounded numbers.

(c) Assumes cost of network modernization = total investment - cost of network expansion.

(d) An increase in U.S. main lines for 1988 may be due in part to changes adopted that year in the FCC's method of collecting data in this area.

SOURCE: OECD, adapted from ITU *Yearbook of Statistics*, MCI and US Sprint data.

Table 5.4: Public Telecommunications Investment*
Comparative Percentages Devoted to Network Modernization
The United States and Other Large Countries 1980-1989**

In a recent survey of the BOCs and the top 15 independents conducted by *Telephony* statisticians, the respondents reported that, on average, they would apportion 28.5 percent of their 1990 budget for capitalized labor. MESA has stated that carriers in Japan, Hong Kong, and Singapore expense at least a portion of their labor costs; MESA asserts that capitalization of such costs would increase Japan's total telecommunications investment figure by more than 20 percent per year.[607]

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[606] We refer here to initial labor costs, such as those incurred for installation. Other labor costs, such as maintenance and repair, are usually expensed.

In the attempt to gauge the effect of this potentially significant adjustment to our investment figures, NTIA surveyed representatives of the telecommunications community from each of the Group of Seven countries. We were unsuccessful in obtaining definitive information on the accounting treatment used in each case and the specific magnitude of the effects. The ITU/OECD data center that we recommend should collect this and related information on a regular basis.[608]

COUNTRY	AVERAGE ANNUAL INVESTMENT PER MAIN LINE FOR MODERNIZATION (U.S. $)(a)	RANKING
Germany	255.48	1
Japan	193.81	2
United States	189.92	3
Italy	185.29	4
France	168.90	5
Canada	149.04	6
United Kingdom	86.49	7

* Capital investment by public telecom operators excluding land and buildings. Unadjusted for differing treatments for labor costs and CPE inclusion.

** Assumes cost of network modernization = total investment - cost of network expansion (estimated as US $1500 x increase in number of lines).

*** These countries represent the seven largest among all OECD members plus Singapore based on the most recent GNP or GDP data available.

(a) Constant 1987 U.S. dollars (adjusted for inflation and exchange rates).

SOURCE: OECD, adapted from *ITU Yearbook of Statistics;* MCI and US Sprint data.

Table 5.5: Average Annual Public Telecommunications Investment* Expenditures for Network Modernization in The United States and Other Large Countries*** 1980-1989**

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[607] *MESA Rebuttal, supra* note 553, at 6.

[608] *See* Appendix D.

Nonetheless, our survey did determine that the major carriers in each of these countries apparently, as a general practice, capitalize their own labor costs incurred during network modernization activities. For such work performed by others on behalf of the carriers, it is less clear what the respective policies may be. The capitalization impact apparently differs widely among the carriers. For example, NTT's labor costs as a proportion of total capital investments equaled 10.5 percent in 1988, which is considerably less than the aforementioned U.S. (budgeted) figure and DBP Telekom's 37.9 percent in 1990.[609]

COUNTRY	AVERAGE ANNUAL INVESTMENT PER MAIN LINE FOR MODERNIZATION (U.S. $)[a]	RANKING
Germany	219.17	1
United States	183.03	2
Japan	174.42	3
Italy	171.63	4
Canada	162.89	5
France	137.17	6
United Kingdom	89.81	7

* Capital investment by public telecom operators excluding land and buildings. Unadjusted for differing treatments for labor costs.

** Assumes cost of network modernization = total investment - cost of network expansion (estimated as US $1500 x increase in number of lines).

*** CPE adjustment is -3.0% for the United States, -15.0% for all others.

**** These countries represent the seven largest among all OECD members plus Singapore based on the most recent GNP or GDP data available.

(a) Constant 1989 U.S. dollars (adjusted for inflation and exchange rates).

SOURCE: OECD, adopted from *ITU Yearbook of Statistics*, MCI and US Sprint data.

Table 5.6: Average Annual Telecommunications Investment* Expenditures for Network Modernization Adjusted for CPE Differentials*** in the United States and Other Large Countries**** 1980-1989**

Practices seem to vary, as well: beginning in 1989, France Telecom started expensing the labor cost relating to construction of the "last mile" to the home, but capitalizes other labor costs. Carriers in Italy, Canada, and the United Kingdom all generally seem to capitalize their labor modernization costs. In view of the apparently common treatment of labor costs, broadly speaking, among the seven large countries during the period 1980-1989, no adjustment has been made to the investment figures used in our analysis.

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[609] We have decided to view NTT's practice in this regard as one of capitalization rather than expensing because this is apparently the treatment used in compiling the ITU/OECD numbers that appear in this analysis. France reportedly did not begin expensing "last mile" construction during the 1980-1989 period under examination here.

These comparisons of average public telecommunications investment per main line—adjusted in varying degrees for inflation, exchange rate differences, the varying regulatory status of CPE liberalization, and the prior omission of two major U.S. carriers —provide an approximate picture of the United States and other major countries with respect to recent telecommunications modernization programs.[610] A statistic that would give useful perspective to the comparisons would reflect changes in the rate of investment per line. Coupled with the average expenditures for the period in question, the comparative time series calculations relating to growth rates would provide some indication of future directions for at least the near-term.

Table 5.7 sets forth compound annual growth rates (CAGR) of public telecommunications investment for the seven major countries during the time span 1980-1989. The figures for 1980 and 1989 reflect adjustments for CPE that are equal in magnitude to those used in previous tables, namely, a 3 percent reduction for the United States and a 15 percent reduction for each of the other six countries shown.[611] Similarly, we use the methodology described earlier whereby the portion of investment per line dedicated to modernization is determined to be the residual of total per-line investment minus that used for network expansion.[612] As before, the figures have been converted to constant 1989 U.S. dollars.

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[610] We concur with Darby, ETI, and MESA about the need for systematic comparisons of the accounting treatments of various costs (*e.g.*, for labor) and types of equipment comprising public telecommunications investments used by these countries so as to make all requisite adjustments. *Darby Study, supra* note 548, at 19-20; *ETI Supplemental Comments, supra* note 556, at 7-9; *MESA Study, supra* note 446, at 13, 15. Earlier in this section, we recognized ETI's CPE-related calculations as one of several inputs into our selection of a percentage adjustment. Its requests for similar types of adjustments for other types of equipment do not seem appropriate here, for several reasons. First, ETI supplies no rationale or documentation to support the nature or magnitude of its proposed adjustments. Second, it assumes that the relevant comparison is foreign "monopoly PTOs" (*i.e.*, public telecommunications operators) and the BOCs; as we discuss *supra* notes 20-23 and accompanying text, our definition of infrastructure encompasses the independent LECs, three major interexchange carriers, and Alascom, as well. Therefore, its recommended adjustments to foreign investment figures (*e.g.*, a 100 percent reduction of all expenditures on satellites) are not valid using our broader definition. *See ETI Study, supra* note 550, Data App. at 9. We would also recommend that the question of adjustments be examined with respect to investment by public carriers relating to cable television. It is our understanding that at least one such carrier (DBP Telekom) includes cable TV outlays in the ITU telecommunications investment figures, although the effect is small.

Before meaningful comparisons of this nature can be accomplished, a systematic inventory of equipment and account practices must be performed across countries.

[611] We recognize that investment is sensitive to variations in the business cycle, and that it is difficult to identify growth or recessionary trends for individual or even small "clusters" of years. Coupled with the other investment-related measures developed in this chapter, however, we believe CAGR analysis can provide useful insights.

Given these adjustments, the United Kingdom and Germany rank first and second, respectively, and the United Kingdom has consistently led the seven countries with the most positive modernization growth rates from 1980 to 1989. In terms of investment per main line for modernization, the United Kingdom placed first with a compound annual growth rate of 7.1 percent. The United States places seventh, with a compound annual growth rate of negative 8.1 percent.[613]

A comparison of the country modernization rankings for average (adjusted) investment per line (Table 5.6) and average compounded annual growth rates (Table 5.7) provides a broad ordering of the seven countries. If the rankings in each category receive equal weighting, then a rough composite can be developed. In our system, a top placement receives seven points, second receives a six, third a five, fourth a four, fifth a three, sixth a two, and seventh a one. The combined scores yield the following ordering:

As in the case of the individual rankings, Germany is top-rated for the composite, while the United States achieves fourth place in Table 5.8. These comparisons omit any adjustments for capitalization of network-related labor costs because of a lack of data. However, as discussed above, we do know, based on our survey results, that the seven large countries, as a general practice, tend to capitalize these costs.

Our estimates indicate that the United States is neither top- nor bottom-ranked among the seven major countries. In the various scenarios studied, Germany's investment totals for modernization of the telecommunications infrastructure were greater than most of the other six during the 1980s. Four of the countries—including the United States— exhibited a declining rate of investment for modernization activities over the time span, while, Germany and Italy registered a substantially positive CAGR during the period. In particular, the United States, Japan, Canada, and France earned negative CAGR values for their per-line investment directed to modernizing their public networks. However, this may indicate only that the United States undertook more of this investment earlier than other countries.

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[612] *See supra* notes 600-601 and accompanying text.

[613] The results in Table 5.7 differ in several ways from the CAGR calculations of Darby (based on MESA's Table 3) and ETI (based on earlier OECD data). Among the differences are a lack of focus on modernization data; no adjustments for CPE and labor costs; and a time interval beginning in 1984 (rather than 1980). With these methodological differences, the CAGR for the United States is a smaller negative number (-1)in the Darby computation (ETI provides no figure for the United States).

As discussed above, some parties have argued that the AT&T divestiture, and particularly the imposition of the AT&T Consent Decree's "line of business" restrictions, have affected the rate of telecommunications infrastructure development in this country. As set forth in Table 5.9, we compare U.S. public telecommunications investment for the post-divestiture period (1984-1989) to the corresponding figures for the period 1980-1983.

COUNTRY	INVESTMENT PER MAIN LINE FOR MODERNIZATION (U.S. $)[a]		CAGR (%)	RANKING
	1980	1989		
United Kingdom	52.13	96.45	7.1	1
Germany	151.84	238.23	5.1	2
Italy	165.32	209.89	2.7	3
Canada[b]	194.26	159.34	(2.2)	4
Japan[c]	183.58	150.54	(2.2)	5
France	155.06	94.19	(5.4)	6
United States	189.33	88.16	(8.1)	7

* Capital investment by public telecom operators excluding land and buildings. Adjusted for differing treatments of CPE inclusion.

** Assumes cost of network modernization = total investment - cost of network expansion (estimated as US $1500 x increase in number of lines).

*** These countries represent the seven largest among all OECD members plus Singapore based on the most recent GNP or GDP data available.

(a) Constant 1989 U.S. dollars (adjusted for inflation and exchange rates).

(b) Before rounding, Canada's and Japan's CAGR is equal to -2.1755 and -2.1784, respectively.

(c) If an adjustment is made for capitalization of labor costs, the new investment-per-line figures for 1980 and 1989 would be $220.30 and $88.16, respectively, but would not affect the CAGR or ranking (assuming both figures are affected by the same 20% adjustment).

SOURCE: OECD, adapted from *ITU Yearbook of Statistics* data; MCI and US Sprint data.

Table 5.7: Compound Annual Growth Rates—Public Telecommunications Investment* Expenditures for Network Modernization in the United States and Other Large Countries*** 1980-1989**

From Table 5.9, it can be seen that investment for network modernization, average investment per main line related to modernization, and compound annual growth rates were all lower for the period 1984-1989 than for the interval 1980-1983, while expansion investment rose. Differences for these two time periods are relatively small for investment for network modernization (-15.2% when pre-divestiture is compared to the post- divestiture period) and average investment per line (-18.3%). However, in comparing the pre-divestiture to the post-divestiture period, investment for network expansion increased 405.6% and CAGR decreased 251.4%. The large difference in investment for network expansion and CAGR for the two intervals can be attributed

COUNTRY	RANK AVG. INV./LINE	RANK CAGR(a)	TOTAL POINTS(a)	COMPOSITE RANK
Germany	1	2	13	1
Italy	4	3	9	2
Japan	3	5	8	3
United Kingdom	7	1	8	3
United States	2	7	7	4
Canada	5	4	7	4
France	6	6	4	6

* Capital investment by public telecom operators excluding land and buildings. Adjusted for differing treatments of CPE inclusion.

** Assumes cost of network modernization = total investment - cost of network expansion (estimated as US $1,500 x increase in number of lines).

*** These countries represent the seven largest among all OECD members plus Singapore based on the most recent GNP or GDP data available.

(a) For country rankings by average investment per line, see Table 5.6; for rankings by compounded annual growth rate, see Table 5.7. Points awarded on the basis of 7 points for 1st place, 6 points for 2nd, 5 points for 3rd, 4 points for 4th, 3 points for 5th, 2 points for 6th, and 1 point for 7th. Each pair of points for a given country is given equal weighting.

SOURCE: OECD, adapted from *ITU Yearbook of Statistics*, MCI and US Sprint data.

Table 5.8: Composite Rankings: Compound Annual Growth Rates and Public Telecommunications Investment* Expenditures for Network Modernization in The United States and Other Large Countries*** 1980-1989**

to the fact that the numerical bases are quite small and, thus, are susceptible to sizeable percentage swings. We would encourage researchers to extend this analysis by further refining the data and exploring what factors potentially explain the trends observed.[614] For purposes of our international investment comparisons, we believe that the current lack of post-divestiture data renders that period less desirable than a longer span, such as 1980-1989 (whose results also appear in Table 5.9), when averaging is an important part of the analysis and when important changes in regulatory or market structures occur at different times in different countries.[615]

CRITERIA	1980-1983	1984-1989	1980-1989
Investment for Network Modernization(a)	96.4%	81.8%	86.6%
Investment for Network Expansion	3.6%	18.2%	13.4%
Average Investment Per Line(b) for Network Modernization	$208.64	$170.13	$183.03
CAGR(c), Average Investment per Line for Network Modernization	(3.7)%	(13.0)%	(8.1)%

(a) Assumes cost of network modernization = total investment - cost of network expansion (estimated as US $1500 x increase in number of lines).

(b) Capital investment by public telecom operators excluding land and buildings. Adjusted for CPE differentials. Constant 1989 U.S. dollars (adjusted for inflation and exchange rates).

(c) Compound annual growth rate.

SOURCE: OECD, adapted from *ITU Yearbook of Statistics*, MCI and US Sprint data.

Table 5.9: Comparative Public Telecommunications Investment in The United States 1980-1989 (Selected Years)

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[614] One refinement would be to isolate the BOCs' investment for the periods to be compared. Another would be to specifically compare a lengthier interval for the post-divestiture period to a pre-divestiture span of equal duration. Perhaps most important of all would be to conduct tests for statistical significance, correlation, and—ideally—causation with respect to the relationship between the line-of-business restrictions and infrastructure development, separating out the effects of the economy and other factors.

[615] For example, major restructuring of the telecommunications industries in these countries occurred at different times during the 1980s: the United Kingdom in 1984, Japan in 1985, France in 1986, and Germany in 1989; in addition, the European Commission's 1987 "Green Paper" on telecommunications addressed many of the issues confronting the emergence of a unified European Community in 1992.

C. INFRASTRUCTURE EXPENDITURES: PROBING THE "WHYS" AND "WHEREFORES"

The above analysis attempts to identify which of the largest countries invest most heavily in modernizing their infrastructure.[616] Lack of data has constrained the comparative time series in several ways, requiring numerous assumptions and estimates.

A critical element of our study is the method developed by the OECD for estimating roughly the cost of public network modernization over a given time period, by subtracting the cost of network expansion from total public telecommunications investment. That method simplifies reality in several ways. First, it assumes that network modernization and expansion are mutually exclusive; in actuality, a given capital expenditure (*e.g.*, a new digital switch) could meet both needs simultaneously. Second, it is conceivable that an investment occurs for other than these two reasons, such as maintenance or repair. Third, the singular use of $1500 as the cost of a new line masks costs differences over time and between countries.

Nonetheless, although imperfect, the method—for purposes of this study—would seem to represent an improvement over one that compares telecommunications investments in aggregate. Under the latter methodology, straight comparisons of total investments take no account of diverse underlying rationales for the expenditures. This could result in overly simplistic conclusions. For example, one could argue that because both the United States and Portugal averaged about $200 per line in telecommunications investment (unadjusted) during 1980-1989, they should be similarly ranked (see Table 5.1). However, when further examination (Table 5.2) suggests that, under the assumptions discussed above, Portugal spent 46.8 percent of its investment for modernization activities while the United States expended 86.6 percent for these purposes, a very different picture emerges.

In the remainder of this Chapter, we examine several measures that could provide insights into the motivations driving the investment decisions of public telecommunications providers in the United States and the six other large countries. These measures include telephone penetration rates and network usage, deployment of certain major telecommunications technologies, and service quality.

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[616] A major concern that we have about the usefulness of investment comparisons centers on the efficiency of a given country's expenditures. A high investment level should not necessarily be equated to an efficient, or optimal, level. We find merit in a suggestion by the FCC's Dr. Kenneth Stanley to tie productivity performance measures to capital outlays in order to evaluate the efficiency of the country's investment program. Ultimately, we look forward to the emergence of a market-based litmus test to assure the efficacy of any such program.

1. Telephone Penetration Rates and Network Usage

An important means of distinguishing the infrastructure development of the various countries is to compare their relative rates of telephone penetration. A second useful comparison centers on network usage. Both the ITU and AT&T collect annual data on usage based on responses to questionnaires sent to telephone administrations and companies throughout the world. Although both sources are widely used, we rely here on AT&T's factbook, *The World's Telephones,* because its reported statistics are more complete and more current than those of the ITU.

We look first at penetration rates. Table 5.10 ranks the OECD countries and Singapore by total (*i.e.*, business and residential) access lines[617] per 100 population. The U.S. penetration rate (49.0 lines per 100 population) ranks seventh out of 25 countries, trailing several northern European countries, Switzerland, and Canada.[618] Sweden (66.7 lines per 100 population) far surpasses all other countries shown.[619] Table 5.11 demonstrates that the United States penetration rate is higher than most of the other large countries. Only Canada's 53.4 lines per 100 population surpasses the U.S. figure of 49.0 as of January 1, 1989.[620]

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[617] Use of an access lines as a unit of measure rather than main lines tends to increase the penetration rates for countries with sizeable PBX bases compared to those that invest less heavily in PBXs. *See supra* note 593.

[618] The U.S. rate may seem low to many industry observers. This impression is likely attributable to the choice of units—lines per 100 population. More familiar to some is the FCC/U.S. Census Bureau measure, percentage of households with telephones. Using that measure, in November 1990 the nationwide U.S. figure was 93.3 percent. *See infra* note 1087 and accompanying text.

[619] Swedish Telecom independently confirms the validity of the number and similarly claims the top ranking. *See* Comments of Swedish Telecom Group at 5.

[620] Other data submitted for the record in this proceeding show a similar trend. For example, ETI presents telephone access line density using access lines per capita for the year 1988, graphically showing that Germany, France, the U.K., and Japan all have lower such rates than the United States. *ETI Study, supra* note 550, at 8. Omitted from the comparison is Canada, the front-runner in Table 5-10; because AT&T is the source of the ETI numbers, it is probable that Canada's figure would be higher than that of the United States, just as in 1989. MESA's comparison sets forth the number of access lines per 100 households using statistics reported by British Telecom. *MESA Study, supra* note 446, at 14, Table 4. Although this ranking system places France (97.7) ahead of the United States (92.9), the latter trails Canada (106.2) while surpassing Germany (90.7), the U.K. (86.4), and Japan (81.1) for the year 1988 in an ordering similar to our tabulation. Again, Italy is not analyzed. In a scenario that recurs frequently in this chapter, different (continued...)

When cellular penetration rates are compared, as shown in Table 5.12, the United States trails Canada and the United Kingdom by a relatively slight amount. On the other hand, in terms of total number of subscribers, Americans outnumber the next largest group of users by more than four to one. It is clear that all of these countries have many potential customers to reach: none currently has a penetration rate greater than 2.2 percent. As advanced societies become increasingly mobile, cellular penetration will probably grow substantially.

These comparisons of telephone penetration rates distinguish among countries in terms of the relative stage of development of their infrastructures. Our findings show, not surprisingly, that the United States is one of the most developed large countries as measured by total access lines per 100 population. This suggests that the United States should be able to concentrate on modernization programs rather than expansion; the investment statistics presented in the previous section support the notion that the United States is, indeed, taking this approach.

This relatively high level of development affects U.S. investment scenarios in another way. As ETI notes,[621] it is more expensive to install subscriber lines for the first time than it is to maintain and add to existing lines. This engineering reality means that all other things being equal, a U.S. telephone company needs a smaller capital budget to meet customer requirements for subscriber lines than its counterpart in a less developed telecommunications system.

There is a demand-side effect, as well. AT&T presents this view in *The World's Telephones*:

> The ever-higher number of access lines represents the increased usage of the telephone (for local, long distance, and international calling) and the demand for a greater variety of new products.[622]

A second criterion for distinguishing among public telecommunications systems is network usage. Table 5.13 presents comparisons based on two ratios that are designed to gauge such usage. In terms of both total calls per capita and total calls per access line, the United States leads the other six large countries by a substantial margin.

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620 (...continued from preceeding page) sources and units of measure (*e.g.*, per capita versus per household) yield different results, but the trends at least in this case are broadly consistent.

[621] *ETI Study, supra* note 550, at 7.

[622] AT&T, *The World's Telephones* at i (1990).

COUNTRY	LINES PER 100 POPULATION(a)	RANKING
Sweden	66.7	1
Denmark	55.1(b)	2
Switzerland	54.1	3
Canada	53.4	4
Iceland	51.1	5
Finland	49.9	6
United States	49.0	7
Norway	47.8	8
Australia	46.6	9
Germany	46.3	10
France	45.2	11
Netherlands	43.7	12
New Zealand	43.2	13
Luxembourg	42.6(b)	14
Japan	42.2(c)	15
United Kingdom	41.4	16
Belgium	40.1	17
Austria	40.0	18
Greece	36.2	19
Italy	34.9	20
Singapore	34.6	21
Spain	28.1(c)	22
Ireland	22.5(c)	23
Portugal	17.8	24

* OECD members plus Singapore.

(a) Includes business and residential access lines.
(b) 1988 data.
(c) Estimated by reporting country.

SOURCE: AT&T, *The World's Telephones*, Table 18 (1990).

Table 5.10: Telephone Penetration Rates in Selected Countries* (January 1, 1989 Data)

These results suggest several basic findings. First, the country with the largest number of private networks, the United States, also has the highest calling volume on its public network. This may reflect, in part, a high incidence of private systems that are based on the public network or U.S. users' perception that each type of network should and does have an important role to play in this country. Second, as ETI claims,[623] usage is one indication of the quality of telephone service in the United States, and the U.S. lead in this category is another indication that the United States has a very high quality infrastructure of public and private networks. The top ranking may also reflect to some extent demand that has been stimulated by dramatically reduced long distance rates,[624] the growing popularity of 800 and other advanced services, and an increasingly global economy.[625]

COUNTRY	LINES PER 100 POPULATION	RANKING
Canada	53.4	1
United States	49.0	2
Germany	46.3	3
France	45.2	4
Japan	42.2(a)	5
United Kingdom	41.4	6
Italy	34.9	7

* These countries represent the seven largest among all OECD members plus Singapore based on the most recent GNP or GDP data available.

(a) Estimated by reporting country.

SOURCE: AT&T, *The World's Telephones*, Table 18 (1990).

Table 5.11: Telephone Penetration Rates in the United States and Other Large Countries* (January 1, 1989 Data)

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[623] *ETI Study, supra* note 550, at 10.

[624] For example, AT&T's direct distance dialing (DDD) rates have declined in excess of 40 percent in nominal dollars (more than 55 percent in inflation-adjusted dollars) since 1984. *AT&T 1990 Annual Report* 19.

[625] AT&T expects the "booming" demand for international calling to continue, with the anticipated "surge" in voice, image, and data calling to reach a record $14 billion in U.S. international billings by 1995. *Id.* at 2-3, 6-7.

According to OECD, communications prices and the level of communications expenditure appear to be negatively correlated: as prices decrease, consumption rises "by more than would be expected."[626] Based on OECD's study of its 24 member countries:

> Countries with cheap telecommunications services spend a higher proportion of GDP [Gross Domestic Product][627] on telecommunications than do countries with expensive services, usually because they have higher penetration rates.[628]

We believe that recent U.S. regulatory changes such as increased competition in long distance markets and regulatory pricing reforms, currently being emulated by many of

COUNTRY	TOTAL SUBSCRIBERS	PENETRATION PER 100 POPULATION	RANK
Canada	582,552	2.2(a)	1
United Kingdom	1,220,000	2.2(a)	2
United States	5,283,000	2.0	3
Italy	410,060	0.7(b)	4
Japan	867,200	0.7(b)	5
France	322,500	0.6	6
Germany	351,490	0.6	7

(a) Due to rounding Canada and United Kingdom seem equally ranked, however, United Kingdom is equal to 2.155 before rounding.

(b) Due to rounding Italy and Japan seem equally ranked, however, Italy is equal to .717 before rounding.

SOURCE: Cellular Telecommunications Industry Association, press release Mar. 18, 1991, at 1; European Mobile Communications Report 53, June 9, 1991, at 18.

Table 5.12 Total Cellular Subscribers and Penetration per 100 Population

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[626] *OECD Report, supra* note 590, at 102.

[627] Gross domestic product (GDP) represents the total final output of goods and services produced within a country accruing either to residents or non-residents. In contrast, gross national product (GNP) includes incomes from foreign countries accruing to residents and excludes incomes earned domestically accruing to nonresidents abroad. *See Competitiveness Report, supra* note 184, at 189.

[628] *OECD Report, supra* note 590, at 101-103.

our major trading partners, have played a pivotal role in causing these lower prices, better services, and increased demand.[629]

COUNTRY	TOTAL CALLS PER CAPITA	RANK	TOTAL CALLS PER ACCESS LINE	RANK	COMBINED RANK
United States	1,721	1	3,511	1	1
United Kingdom(a)	828	2	2,002	2	2
Canada(a)	750	3	1,405	3	3
Japan	553	4	1,307(c)	4	4
Germany	496	5	1,072(c)	5	5
France(b)	395	6	874	7	6.5
Italy	370	7	1,060	6	6.5

* The Total Calls statistic is calculated by summing the number of local, long distance, and international calls for each country for the year 1989.

** These countries represent the seven largest among all OECD members plus Singapore based on the most recent GNP or GDP data available.

(a) 1988 local and international, 1989 long distance calling volumes.

(b) 1988 local, long distance, and (ETI estimated) international calling volumes.

(c) estimated by reporting country.

SOURCE: AT&T, *The World's Telephones*, Tables 15-18 (1989; 1990); *ETI Study*, Data Appendix at 3.

Table 5.13: Network Utilization Ratios—Total Calls Per Capita and Per Access Line* in The United States and Other Large Countries during 1989**

Network usage also provides another dimension to the development issue. If calling volume is relatively large, then economies of scale may occur in the network.[630] If the existing level of demand permits such economies to occur, then the cost of constructing new network facilities will be less than when the volume is insufficient to achieve the lower unit costs. For countries with different usage levels, this factor would affect the relative sizes of their investment expenditures and, if unrecognized, would lead to a misinterpretation of the results in any comparison. Although certainly plausible, we can adduce no evidence in the record that helps us to identify either the existence or the magnitude of such an effect on the investment ratios presented in this report.

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[629] *See infra* notes 712-714 and accompanying text.

[630] Generally, economies of scale are said to exist where a given percentage increase in inputs (*e.g.*, labor and capital) to the productive process results in a greater percentage increase in output. In economic terms, the phenomenon occurs where long run average costs (LRAC) are declining over the entire range of output in a given market as determined by the relevant portion of the demand curve. Although, historically, many have considered the telephone industry to be a "natural monopoly"—that is, it is more efficient to have a single supplier rather than multiple suppliers because of the existence of significant economies of scale or scope—recent evidence calls into question this premise. *See infra* notes 983-987 and accompanying text. However, it is possible to reap capital budget savings from realized scale economies that fall short of meeting the cost standard for a natural monopoly, namely, a declining LRAC over the entire range of industry demand.

Taken together, the telephone penetration and network usage statistics enable us to refine our previous analysis of investment expenditures. Our analysis confirms the notion, widely expressed in the comments, that the United States is a nation with a highly developed infrastructure, characterized by a very high access-line density, a robust level of telephone usage, and a heavy emphasis on "modernization." At the same time, the U.S. annual growth rate in public telecommunications investment per line related to modernization during the 1980s, on average, was negative. While a definitive ranking of U.S. average public telecommunications investment per line vis-à-vis the other major countries of the world is problematic, it is possible, but subject to challenge. It appears that the United States is neither first nor last among the world's seven largest countries in this regard.

This contrasts markedly with a country such as Italy, which was among the top performers during the 1980s both in terms of magnitude and growth of investment expenditures but, because of its relatively low penetration and usage levels, emphasized expansion of subscriber lines more than the United States. Canada's situation appears to be the inverse of Italy: among the highest in penetration and usage, and in the lower echelons in terms of quantity (but not proportion) of modernization outlays. The United Kingdom appears to be similar to Canada, but much lower in penetration rate and somewhat lower in terms of its percentage devoted to modernization activities.

While exceptional in their level and proportion of public network modernization expenditures, Germany and Japan are mid-range in penetration and usage. They may be distinguished from each other by Germany's positive average annual growth rate during the 1980s and Japan's negative rate. France generally rates in the middle in the investment categories, but finishes in the lower ranges in the network usage category.

2. Deployment of Technologies

Virtually every commenter addresses to some degree the topic of technology and its impact on the evolution of the telecommunications infrastructure.[631] NTIA recognizes the tremendous importance of technological change as it has affected this portion of the communications industry. In Chapter 4, we summarize significant technological developments that are occurring in the United States. In this chapter, on the related but separate issue of intercountry technology comparisons, our review focuses on several key facets of the public network debate—that is, comparative deployments of advanced switching capabilities, fiber optic cable and SS7.[632]

a. Switching Capabilities

The most contentious of the technology debates in the record centers on the issue of the most appropriate switching comparison. MESA asserts that a principal measure of network modernization is the degree of switching digitization, measured by number of lines served by digital switches. As we discussed in Chapter 4, digital switches are the most modern and technically advanced generation of switches.[633] Based on a 1990 survey of LECs that accounted for 95.4 percent of all U.S. access lines in 1989, MESA claims that the United States currently trails France and Canada in the percentage of digital switches installed (as measured by lines served). By 1994, it claims, U.S. LECs will also trail the United Kingdom and Japan. Among the large countries, the United States' percentage of digital switches will apparently surpass only Italy and Germany's Deutsche Bundespost Telekom by the mid-1990s.[634] Given that digital switching has become the preferred equipment of choice for many applications,[635] the declining U.S. ranking takes on added significance. Table 5.14, which is based on MESA's tabulations, states the specific percentages and rankings.

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[631] AT&T and Bellcore submitted two of the more detailed assessments of present and future technological trends. *See* Comments of AT&T, App. A; Joint Submission of Bellcore, Attach. 3.

[632] Clearly, there are many more possible technology comparisons that could be attempted. We limit our attention to the above-mentioned areas for two reasons. First, commenters underscore the importance of advanced switching, fiber optics, ISDN, and SS7 more than any other technologies. Second, meaningful data are lacking for international comparisons of technologies other than for these four.

[633] *MESA Study, supra* note 446, at 6-8.

[634] According to press reports, Deutsche Bundespost Telekom officials and independent experts believe that technical problems, confusion over standards, and poor promotion slowed network digitization in Germany. *See, e.g., Germany Marches On,* Communications Week, Feb. 4, 1991, at 35.

[635] *See supra* notes 442-443 and accompanying text.

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ETI responds that fully-digital switches represent a subset of a potentially more important category: computer-controlled switches.[636] According to ETI, the latter provides the more important basis for comparison because—as recognized by MESA— switches that are not computer-controlled can only access the "most basic services."[637] ETI cites the case of France, which currently leads in the proportion of digitized lines, but has 1.5 times as many non-computer-controlled switches as the United States. AT&T similarly argues that both analog and digital electronic, or computer-controlled, switches can be

COUNTRY	% DIGITAL LINES	1989 RANK	% DIGITAL LINES	1994 RANK
France	70.7	1	86.5	3
Canada(a)	51.4	2	87.5	2
United States(b)	42.5	3	68.2	5
United Kingdom	38.0	4	92.0	1
Japan	31.0	5	76.0	4
Italy	16.1	6	NA	NA
Germany	2.6	7	38.0	6

* These countries represent the seven largest among all OECD members plus Singapore based on the most recent GNP or GDP data available.

(a) Includes data for Bell Canada, British Columbia Telephone, and Alberta Telephone.

(b) Disaggregated rates for 7 RBOCs and 40 independents for 1989 and 1994, respectively: RBOCs (35.3%, 57.0%); 12 major indeps. (75.0%, 87.0%); and 28 small indeps. (72.1%, 90.2%). According to the FCC, in 1989, the proportion of Bell central offices with digital technology was 47.3%; it is projected to be 75.3% in 1994; (c) 100 percent digital local exchanges expected in 2007.

SOURCE: *MESA Study*, Tables 1, L; footnote (c): Telephony, Feb. 4, 1991, at 35; Facsimile transmission from Peter Bross, Esq., German Ministry for Post and Telecommunications to James McConnaughey, NTIA, June 18, 1991.

Table 5.14: Percentage of Digital Switches by Subscriber Lines
The United States and Other Large Countries* 1989, 1994

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[636] As discussed in Chapter 4, there are both analog and digital computer-controlled switches—that is, the switching fabric of a computer-controlled switch could be analog or digital. *See supra* notes 440-443 and accompanying text.

[637] *ETI Study, supra* note 550, at 13.

updated more easily and maintained more economically than older technologies.[638] Both ETI and AT&T rank the United States ahead of the other large countries in the percentage of computer-controlled switches, with only France's percentage (69.7 percent) close to the U.S. figure (76.2 percent) in 1988.

Table 5.15 displays updated (1989) statistics and an expanded coverage of countries for the percentage of computer-controlled, or electronic, switches as developed by ETI and AT&T. As is readily seen, the United States remains in the top position, with an electronic switching percentage of subscriber lines approaching total penetration (96.6 percent).

An alternative means of comparing the conversion rates for electronic switching among countries employs central offices, rather than lines served, as the unit of measure. Based primarily on survey data collected by MESA from the principal carriers in each country, the comparisons yield a similar ranking in which the United States leads the other large countries by a substantial margin. In addition, the data permit the calculation of estimated electronic switch percentages for the year 1994. At that point, it is anticipated that the United States will be joined at the near-total conversion level by at least France and Canada. In the sense that most of the Group of Seven countries will have achieved 90 percent or higher electronic switch penetration by the mid-1990s, the current U. S. lead in this category will have been effectively lost. These results appear in Table 5.16.

In our view, both types of analyses present useful comparisons. This country's proportion of digital switch installations over time reflects the conversion rate to a state-of-the-art technology that will provide for new services using expanded bandwidth and requiring higher transmission speeds. To the extent that digital switching is a desirable technology in 1994, the United States is projected to trail the other four major countries for which projections are available. In addition, it is important to know the pace of the changeover to electronic switching from the electromechanical generation of switches. Such switches are still prevalent in some countries—in 1989, 97.2 percent of Germany's local switches and 54.0 percent of Japan's local switching machines were electromechanical—but the clear-cut trend for large and most smaller countries is toward digital electronic switching.[639] To the extent that other countries have substantial amounts of electromechanical equipment, they may be able to "leap frog" the United States, with its large quantities of electronic analog switches, in deploying the most advanced digital technology.[640]

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[638] Comments of AT&T at 11. AT&T uses the same data source but different terminology.

[639] *See, e.g.*, *MESA Study, supra* note 446, Tables K, L, and M for trends in this direction over the time span 1984-1994; AT&T, *The World's Telephones* Table 7 (1989); *ETI Study, supra* note 550, at 13. *See also* Vanston and Lenz, *Technological Substitution in Switching Equipment for Local Telecommunications* (continued...)

COUNTRY	% ELECTRONIC LINES	1989 RANK
United States[a]	96.6	1
France	75.9[b]	2
Canada	57.9	3
Japan	44.8[b]	4
United Kingdom	23.5[c]	5
Italy	17.6[d]	6
Germany	1.5[c]	7

* These countries represent the seven largest among all OECD members plus Singapore based on the most recent GNP or GDP data available.

(a) The FCC reports that 73.9% of central offices featured either analog or digital stored program control capabilities in 1989.

(b) Estimated by reporting country.

(c) Under the definition used in this report, the number of digital switches in the given countries should be smaller than the number of electronic switches. A discrepancy between the percentage of electronic switches and digital switches per subscriber line in this table and the preceding Table 5.14 may exist because the data for both tables is derived from different sources which may use different methodology for developing statistics.

(d) This figure reflects the percentage of central offices that are electronic; the corresponding figure for lines is not available.

SOURCE: AT&T, *The World's Telephones* Table 7; FCC, *Trends in Telephone Service*, Table 13, (Aug. 7, 1991).

Table 5.15: Percentage of Electronic Switches by Subscriber Lines in The United States and Other Large Countries* during 1989

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639 (...continued from preceeding page)
(submitted with Comments of Technology Futures, Inc.) (electromechanical switches currently serve about 10 percent of total access lines and will serve less than one percent by 1993; during the 1990s the number of access lines on analog stored program control switches will fall dramatically, serving less than one percent of all lines by the year 2000).

[640] This phenomenon appears to explain the projected trailing position of the United States in digital switching for 1994. Other countries that were slower than the United States in deploying advanced electronic analog switching technology are now bypassing that generation of technology and moving directly from electromechanical to digital switching.

COUNTRY	1989		1994	
	% ELECTRONIC OFFICES	RANK	% ELECTRONIC OFFICES	RANK
United States(a)	92.6	1	98.2(b)	2
France	84.6	2	98.7	1
Canada(c)	68.5	3	96.3	3
United Kingdom	59.5(d)	4	92.0	5
Japan	52.7	5	93.0	4
Italy	17.6	6	NA	
Germany	2.8	7	NA	

* These countries represent the seven largest among all OECD members plus Singapore based on the most recent GNP or GDP data available.

(a) Disaggregated rates for 7 RBOCs and 40 independents for 1989 and 1994, respectively: RBOCs (93.8%, 100.0%); 12 major indeps. (91.0%, 93.0%); and 28 small indeps. (72.9%, 94.7%). According to the FCC, in 1989, the proportion of Bell central offices with stored program control was 73.9%; it is projected to be 94.0% in 1994.

(b) The source data summed to 108.16%; percentage in table reflects deflation of component numbers such that their sum equals 100.0%.

(c) Includes data for Bell Canada, British Columbia Telephone, and Alberta Telephone.

(d) As of March 31, 1990, British Telecom's proportion of electronic switches equaled 67.0%. Letter from J.W. Butler, General Manager-Corporate Strategy, BT, to Ron Hubert, MESA Inc., May 10, 1990.

(e) This represents an estimate based on BT projections regarding digital switching deployment by lines (data for electronic switches by central office not available).

(f) NTT recently announced that it plans to complete its digitization of all switches by 1998. "NTT Moves Up Its Medium-& Long-term Digitization Plans," *New Era*, No. 122 (1990).

SOURCE: *MESA Study*, Tables L, M; FCC, *Trends in Telephone Service*, Table 13 (Aug. 7, 1991); *British Telecom Supplementary Report* at 13.

Table 5.16: Percentage of Electronic Switches by Central Offices The United States and Other Large Countries* 1989, 1994

b. Fiber Optics

In Chapter 4, we discussed U.S. deployment statistics for fiber optics, which indicate that deployment is increasing in all parts of the public network other than the portion of the loop that reaches the customer's premises. As we have noted, fiber optic cable possesses several advantages relative to "traditional" copper cable.[641] These include its high transmission capacity, high quality, low space requirements, and less susceptibility to interference. MESA states that the United States remains the world's leader in the development and implementation of optical fiber transmission capacity, with over 200,000 fiber sheath-miles installed in U.S. public networks by the end of 1989. To control for the fact that the gross amount of fiber deployed in a country will be influenced by its geographic size, however, MESA calculated fiber density ratios, measured as kilometers of fiber per thousand square kilometers of territory. Gauged by this standard, the United States ranks much lower relative to some of the other major countries. Table 5.17 reproduces MESA's figures.

The significance of these numbers is not patently obvious. Unlike the switching comparisons, which show the proportion of a nation's switching capacity devoted to a particular technology, the fiber density figures do not compare the deployment of fiber with the deployment of other transmission technologies. Although the concept of weighting the countries' figures by a density factor is attractive, it is not clear that area is necessarily superior to a unit such as population. A major advantage of fiber optics relates to its large capacity for traffic, which appears to be related at least as much to population as square kilometers.[642] As shown in Table 5.18, on the basis of fiber route kilometers per 100 population, the United States was a leader in fiber deployment during 1988-1989.[643]

Recognizing that different technologies are best for different applications, thus far in the United States, optical fibers have found ready application in, first, interexchange facilities and interoffice trunks[644] and, more recently, feeder plant; however, deployment in local distribution plant (*i.e.*, to the home or to the curb) has not yet occurred to any significant degree.[645] There appears to be promise of future widespread fiber use in distribution plant after significant technical challenges in the areas of cost, power, operations, and architecture are successfully met.[646] Overall, fiber will increasingly be the transmission

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[641] *See supra* note 393 and accompanying text.

[642] 1990 estimates show widely different population densities for the Group of Seven countries, ranging from Canada's six people per square mile (ppsm) to Japan's 844 ppsm. In the United States, the figure is 68 ppsm, which seems diminutive compared to France's 252, Italy's 493, the United Kingdom's 601, and Germany's 626. *The 1991 World Almanac and Book of Facts* 695, 709, 712, 722, 723, 762, 765. These, of course, are averages and, therefore, do not necessarily correspond to densities that are relevant for engineering networks in particular regions.

[643] Two other measures could prove useful. Traffic volumes, such as number of messages or minutes of use, could be a relevant gauge, although fiber deployment and traffic volumes may not occur in the same proportion in the network. Perhaps the measure with the greatest potential utility for this analysis would be fiber optics as a percentage of total transmission capacity, especially disaggregated by type of network (*e.g.*, local versus interoffice), but data are difficult to obtain.

The comparison presented in Table 5.18, by itself, is not dispositive, however, because these figures ignore other installed transmission technologies, such as coaxial cable, copper, microwave, and satellite.

COUNTRY	1988 RATIOS	1989 RATIOS	RANK
France	NA	161.80	1
United Kingdom	100.82	NA	2
Germany	45.56	75.43	3
Japan(a)	55.89	NA	4
United States(b)	26.25	34.47	5
Canada(c)	4.52	7.33	6
Italy	NA	NA	NA

* The fiber density ratio is defined as route kilometers per thousand square kilometers of territory.

** These countries represent the seven largest among all OECD members plus Singapore based on the most recent GNP or GDP data available.

(a) Includes NTT only.

(b) Includes seven RBOCs, eight interexchange carriers, GTE, United Telecom, Contel, and numerous small independent LECs.

(c) Includes all Canadian telcos in 1988, and Bell Canada, British Columbia Telephone Company, and Alberta Telephone only in 1989.

SOURCE: *MESA Study*, Table 5.

Table 5.17: Public Network Optical Fiber Density Ratios[*] in The United States and Other Large Countries[**] 1988, 1989

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[644] The proportion of interexchange and interoffice transmission plant that fiber currently represents is approximately 75 percent and 51 percent, respectively. *See* discussion *supra* at 97.

[645] LECs' fiber deployment in subscriber plant presently accounts for some 35 percent of their total fiber mileage installed; "little" of it represents distribution fiber in place. *See Fiber Deployment Update, supra* note 392, at 19, 20, 23.

[646] *Fiber in the loop challenges: Break on through to the other side*, Telephony, Jan. 14, 1991, at 38-40, 42, 44, 46, 48.

medium of choice for many applications (especially where high bandwidth is desired), including cable television[647] as well as public and private telecommunications networks.

COUNTRY	1988		1989	
	RATIOS	RANK	RATIOS	RANK
Canada(a)	0.171	1	0.278	1
United States(b)	0.097	2	0.127	3
United Kingdom	0.043	3	NA	NA
Germany	0.019	4	0.031	4
Japan(c)	0.017	5	NA	NA
France	NA	NA	0.158	2
Italy	NA	NA	NA	NA

* All populations are mid-1989 estimates except Canada (mid-1988) and Germany (1987 census).

** These countries represent the seven largest among all OECD members plus Singapore based on the most recent GNP or GDP data available.

(a) Includes all Canadian telcos in 1988, and Bell Canada, British Columbia Telephone Company, and Alberta Telephone only in 1989.

(b) Includes seven RBOCs, eight interexchange carriers, GTE, United Telecom, Contel, and numerous small independent LECs.

(c) Includes NTT only.

SOURCE: MESA, "A Comparative Assessment of National Public Telecommunications Infrastructures," April 1990, Table 5; *The 1990 Information Please Almanac,* at 167, 188, 194, 212, 214, 271, 278.

Table 5.18: Fiber Route Kilometers Per 100 Population*
in The United States and Other Large Countries 1988, 1989**

c. ISDN

ISDN,[648] in both its initial narrowband version and the planned broadband version, has been the focal point of a major international standards effort. Several Asian and European countries are apparently deploying ISDN at a faster rate than the United States. In 1989,

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[647] The cable television industry has already increased significantly its fiber deployment. In 1990, the industry installed 4083 fiber route-miles, an increase of 85 percent over 1989's figure. Paul Kagan & Associates, *Cable Television Technology,* Mar. 31, 1991, at 3.

[648] *See supra* note 401 for a description of ISDN.

Singapore became the first country to provide universally available (narrowband) ISDN service to its subscribers, after Japanese manufacturer Fujitsu launched the world's first ISDN field trials there in 1985. In 1990, France completed national coverage of its "Numeris" ISDN and achieved international connections with the United States, Japan, Belgium, and Germany.[649] Deutsche Bundespost Telekom plans ISDN coverage to all of western Germany by 1993 and to eastern Germany, whose telecommunications infrastructure will be the focus of a massive rebuilding program called "Telekom 2000," in the period 1993-1995.[650] Japan expects full narrowband ISDN deployment by 1994 and will begin implementation of some broadband functions in 1995.[651] In contrast, the Bell companies registered .1 percent coverage in 1989 and anticipate 49.8 percent by 1994.[652] Table 5.19 presents a synopsis of these ISDN timetables.

The difference between the United States and other countries in ISDN deployment is one of the most striking in our comparisons. As discussed in Chapter 4, development is proceeding in the United States,[653] but not to the degree seen in other countries.
Thus, while the recent release of Bellcore's National ISDN-1 specification for narrowband ISDN has boosted the collective BOC 1994 deployment projection by 26-fold,[654] there appears to be little disagreement that ISDN deployment in Europe and Japan will exceed that in this country for the foreseeable future.[655]

These findings raise a broader series of questions that must be addressed in order to properly evaluate their significance. What ISDN applications exist? What substitutes for ISDN are available? Do customers want what ISDN can offer? How do international standards affect the deployment of ISDN? Many claim that there are too few applications, both in the United States and in other parts of the world.[656]

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[649] Telephony, Jan. 7, 1991, at 32.

[650] *See Germany Marches On,* Communications Week, Feb. 4, 1991, at 35. It should be noted that total coverage is not tantamount to digitization of 100 percent of Germany's local exchanges. Germany plans to provide users with access to digital switches through concentrators, located at analog exchanges serving customers that wish to subscribe to same. *Id.*

[651] T. Kobayashi, *NTT's Investment Trends and Medium and Long-Term Digitalization Plans,* Internal Document (Jan. 1990) (cited in *MESA Study, supra* note 446, at 21). *See also* H. Yamaguchi, *A View toward Telecom Services and Networks in the 21st Century,* NTT Review, Mar. 1990, at 12.

[652] *See Telephone Trends, supra* note 30, at 18, Table 13 (1989 data); Wallace, *RBHCs Revise Schemes for ISDN Rollout,* Network World, Apr. 29, 1991, at 1 (1994 projection). The BOCs' projected growth rate for the five-year period is noteworthy: an increase of 49,700 percent.

[653] *See supra* notes 413-417 and accompanying text, especially Tables 4.2 and 4.3.

[654] The currently projected ISDN conversion rate of 49.8 percent of subscriber lines by 1994 supersedes the BOCs' earlier projection of 1.9 percent for the same year, as submitted to the FCC. *See* Wallace, *RBHCs Revise Schemes for ISDN Rollout,* Network World, Apr. 29, 1991, at 1; BOCs' filings in CC Docket No. 89-624 (Feb. 1990).

[655] *See, e.g., ETI Supplemental Comments, supra* note 556, at 4.

COUNTRY	1989	1990	1993	1994	1995
Singapore	100.0%	100.0%	100.0%	100.0%	100.0%
France	NA	100.0	100.0	100.0	100.0
Germany	NA	NA	100.0(a)	100.0(a)	100.0(b)
Japan	69.0	76.0	92.0	100.0	100.0
United States(c)	.1	.5	NA	49.8	NA
Canada	NA	NA	NA	NA	NA
Italy	NA	NA	NA	NA	NA
United Kingdom	NA	NA	NA	NA	NA

* Coverage is defined as percent of equipped access lines.

** These countries represent the seven largest OECD members plus Singapore based on the most recent GNP or GDP data available.

(a) Applies only to former West Germany.

(b) Applies to reunified country.

(c) FCC data; includes RBOCs only. The FCC also reports 1.9% of central offices converted to ISDN in 1989; 24.2% by 1994.

SOURCE: *MESA Study*, Table 6; Telephony, Jan. 7, 1991, at 32; Communications Week, Feb. 4, 1991, at 35; FCC, *Trends in Telephone Service*, at 19, Table 14 (Aug. 7, 1991); Wallace, *RBHCs revise schemes for ISDN rollout*, Network World, Apr. 29, 1991, at 1.

Table 5.19: Percentage of Narrowband ISDN Coverage* in the United States and Other Large Countries Selected Years**

A major proponent of public ISDN networks, describing them as "an unbeatable way of meeting competition," calls the current lack of applications a "tragedy."[657] Others contend that applications, although slow to develop, are nonetheless emerging as critical mass builds.[658]

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[656] *See, e.g., Where Are The Applications?,* Communications Week, Feb. 4, 1991, at 35, 38-39.

[657] B. Svedberg, "Focus on Europe," presentation before the 1990 National Communications Forum, Chicago, Illinois (Oct. 8, 1990). Dr. Svedberg is Chairman of Ericsson Corp.

[658] *See, e.g., Special report: ISDN Update,* Telephone Engineer & Management, Feb. 15, 1991, at 2.

Apparently, in the view of some users, acceptable alternatives to narrowband ISDN exist. Beginning in the late 1980s, communications managers of large U.S. companies have tended to be skeptical of the benefits of narrow band ISDN, arguing that they can already access ISDN-like capabilities from other sources at a lower cost.[659] Demand for digital services at T-1 and DS-3 rates is quite strong, for example. Private networks also currently provide high-speed dial-up capabilities needed by a number of large customers.[660] Broadband LANS supply other features that narrowband ISDN cannot, although LANs' ability to interconnect is currently limited.[661] Lower speed data interconnectivity is available through PSN capabilities.[662]

Although U.S. deployment of ISDN-capable networks will apparently lag behind the rates planned by other large countries, the demand side shows a different situation. The figures cited above refer to the availability of ISDN, not to the actual subscribership for that service. As part of the "EC 92" initiative,[663] a European government objective is to achieve a five percent subscriber penetration rate in that region by 1993. Researchers claim that, instead, the rate will be less than two—and perhaps even lower than one—percent by that date.[664] One consultant projects U.S. penetration to exceed two percent in 1993.[665] The corresponding figure for Japan appears to be less than one percent, but the growth rate is reportedly "booming" in recent months as the Japanese accelerate their efforts to modernize their network.[666] To attract more users, France Telecom has undertaken extensive market research on user needs and potential ISDN applications. Its review has determined that in France, small businesses and the self-employed will be major users of ISDN. Medium-sized users will respond to access to "super-telephony" and cost savings on data transmission. And for large customers, PBX replacement will be the key to ISDN implementation.[667]

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[659] *See, e.g., A Telco Manager's Answer to ISDN,* Communications Consultant, Aug. 1988, at 47; *What Do Users Want [an ICA Roundtable],"* Telephony, May 16, 1988 at 37.

[660] *Where Are The Applications?,* Communications Week, Feb. 4, 1991, at 35-38. At present, the public switched network does not provide such capabilities on a widely available basis, but such high-speed switched services such as frame relays and SMDS are rapidly emerging. *See Data Demand,* Communications Week, June 17, 1991, at 44-46.

[661] *ETI Supplemental Comments, supra* note 556, at 4.

[662] A recent survey by British consultant Logica found some large users believe that speeds of 9.6 kilobits per second (kbs)—presently available on existing public switched networks—rather than the 64 kbs available on ISDN, are sufficient to satisfy their data transfer requirements.

[663] In 1992, the European Community, or EC, will formally inaugurate a new, higher level of economic and political integration among member countries.

[664] Consulting firms such as Dataquest, Gartner Group, and Ovum have performed studies concluding that the development of ISDN demand in Europe has been slow to date and is expected to remain slow for at least the near future. *See, e.g., Limited growth for ISDN worldwide,* Communications International, Mar. 1991, at 21.

[665] S. Timms, *Initial Services Don't Need Novelties,* Communications Systems Worldwide, July/Aug. 1989, at 16, 17, 19, 22.

[666] *Growth forecast for Japanese network,* Communications International, Mar. 1991, at 15.

CCITT, the international telecommunications standards body, created ISDN as a concept in 1972, and progress in defining global standards has been steady. Narrowband standards have been developed, and broadband standards are being defined.[668] Progress appears to be accelerating. For example, in late February 1991, representatives of U.S. industry reached agreement on standard technical specifications for ISDN in this country, potentially allowing its widespread availability by late 1992.[669] Some observers, however, continue to be skeptical about the strength of the consensus and the concomitant ability actually to implement the standards.[670]

It seems clear that the deployment of ISDN services in the United States will be a function of standards and user demand for applications. Because of our demand-oriented society, only if ISDN services surpass the capabilities of other offerings or reduce costs to users relative to these alternatives will they be commercially successful in this country.

d. SS7

As discussed in Chapter 4, SS7 is an advanced out-of-band signalling system that rapidly passes signalling information in a digital format. By separating the signalling function from the information carrying channel, SS7 permits more efficient use of the network. For example, in an SS7-equipped network, the circuit path for a call is established before the call itself is sent over the network; if a call cannot be completed because no end-to-end circuit is available or the called party's line is busy, the call will not be sent. Other advantages of SS7 include reduced post-dialing delay and equipment holding times; increased information-carrying capacity that permits the design of improved customer services, especially those involving customer interaction with the network or database retrieval; compatibility with international signalling; and two-way signalling. The system

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[667] M. Steckel and M. Fossier, *FRANCE TELECOM: An Insider's Guide* 40 (1991).

[668] However, some commentators view this progress as being too slow. *See Whatever happened to ISDN*, IEEE Review, Oct. 1990, at 357-60.

[669] Telecommunications Reports, Mar. 4, 1991, at 13.

[670] *Will Everyone Dance To This ISDN Tune?*, Communications Week, Mar. 11, 1991, at 33.

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also promotes the development and spread of advanced intelligent network (AIN) technology.

France's rate of SS7 deployment has outstripped that of the United States and other large countries. As presented in Table 5.20, France Telecom achieved complete SS7 implementation during 1990, the same time it put narrowband ISDN fully in place. By contrast, in 1989 the BOCs plus selected independent LECs and IXCs had converted 6.3 percent of their central offices to SS7, a rate similar to the United Kingdom (6.2 percent) and somewhat behind Canada (8.4 percent). By 1994, U.S. telephone companies plan to be at a conversion level of 57.7 percent, which will put the United States behind France, the United Kingdom, and Canada.[671] However, IXCs in the United States have led the world in large-scale SS7 deployment. IXCs had converted 33.8 percent of their offices to SS7 by 1989 and plan to have converted 100.0 percent by 1994.

The reason for this relative lack of U.S. deployment of SS7 by local exchange carriers is unclear. This signalling system, which does not require a fully digital network to realize its benefits, appears to be capable of supporting a wide variety of potential services. Moreover, the current situation is affecting the achievement of a fully competitive interexchange market since the lack of SS7 in LEC end offices has impeded the implementation of equal access for 800 services, one of the fastest growing inter-exchange services. One reason for the relatively slow implementation rate may be the current judicially imposed restrictions on BOC centralized SS7 provisioning on a centralized basis.[672] In Chapter 6, we recommend removal of that restriction.

3. Service Quality

To make an intelligent assessment of the U.S. public telecommunications network, it is not sufficient to know the level of associated investment, nor the proportion of expenditures dedicated to modernization and expansion by the various large countries. Further, stand-alone comparisons of the deployment of a particular technology or groups of technologies are inadequate as bases for determining a given country's standing among its major trade partners. In addition, performance measures are needed to gauge the U.S. status with respect to infrastructure development.

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[671] *See MESA Study, supra* note 446, Tables K, N.

[672] *See infra* notes 795-798 and accompanying text.

COUNTRY	% SS7	1989 RANK	% SS7	1994 RANK
France	47.6	1	100.0(a)	1
Canada(a)	8.4	2	60.2	3
United States(b)	6.3	3	57.0	4
United Kingdom	6.2	4	83.0	2
Germany	NA	NA	NA	NA
Italy	NA	NA	NA	NA
Japan	NA	NA	NA	NA

* These countries represent the seven largest among all OECD members plus Singapore based on the most recent GNP or GDP data available.

(a) France Telecom achieved the 100% level in 1990.

(b) Includes RBOCs and selected independents. The FCC reports 21.0% of BOC equipped access lines possessed SS7 capability in 1989 and projects 73.1% in 1994.

SOURCE: *MESA Study*, Table 8; *France Telecom: An Insider's Guide* at 33 (1990); FCC, *Trends in Telephone Service*, Table 14, February 28, 1991, Table 14.; BOC data filed in Rate of Return Represcription proceeding CC Docket No. 89-624 (Feb. 1990); Wallace, "RBHCs Revise Schemes for ISDN Rollout," *Network World*, Apr. 29, 1991, at 1.

Table 5.20: Percentage of Central Offices with SS7 Capability in The United States and Other Large Countries* 1989, 1994

A critically important criterion in any such evaluation is the quality of service that the public telecommunications network gives its subscribers. Network usage represents one indicator of service quality, but may also reflect other factors, such as low prices.[673] Other measures are also needed to provide more direct barometers of network service quality.

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[673] International price comparisons are attractive in theory, but very difficult to construct in practice. Myriad configurations of service packages, rates, and tariff structures across countries make comparisons a complex undertaking. The process is greatly complicated by the use of subsidies in all countries being examined, including the United States, although many are beginning to follow the lead of the United States in moving toward much greater reliance on cost-based rates. As noted above, the OECD has done substantial research on the subject of comparing composite "baskets" of services for member countries, developing a "harmonised" methodology and "guiding principles" for implementation that appear to hold considerable promise for future analyses. *See OECD Report, supra* note 590, at 23-103, 159-171.

Different nations have developed and are currently employing a variety of quality measures, but most of these are not in common use by the United States and other large countries.[674] One of the few measures used by most of the major trading partners is call failure or blocking. Generally speaking, calls may not be completed when the called party is unavailable, the caller misdials, or the network fails. When the network fails because, for example, circuits are overloaded, or system equipment misperform, then call failure occurs. Call failure is expressed as a percentage of the total number of calls attempted.[675]

Table 5.21 presents call failure data for the United States and five of the other six large nations.[676] The comparisons suffer from a lack of consistency, because, for example, some data are of much more recent vintage than others. Nonetheless, this analysis permits service-quality evaluations that otherwise are generally not obtainable because of the lack of uniformity in the types of measures used by various countries.[677]

As shown, the United States' local and composite (local plus long distance) call failure rates place it behind Japan and Canada, but ahead of Germany, the United Kingdom, and France. With the possible exception of France, more than 98 percent of all attempted calls are transmitted unimpeded in each of the large countries, including the United States; four of the six (including the United States) exceed 99 percent for local calling. France's composite 2.5 percent failure rate includes an unknown amount of successfully completed, low quality calls, so its overall call "success" rate may technically also exceed 98 percent. Japan's figure, which includes only call failures related to plant defects, is understated compared to at least the United States and the United Kingdom, which include failures related to both congestion-caused blockage and equipment breakdowns in their call-failure measures.

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[674] We discuss *infra* the need for more service quality indicators that have widespread applicability.

[675] In some countries, such as Sweden, the complementary percentage is used and is referred to as the call success rate.

[676] Italy did not collect such data as of 1989.

[677] In the past, most OECD countries collected "waiting time" data, *i.e.*, a waiting list for main lines as a ratio of total main lines. However, the United States stopped compiling such data during the early 1980s, because we began to collect access line statistics, instead, with the onset of divestiture. We also question the measure's usefulness in view of definitions of "waiting" that have historically differed by country. For example, waiting time in Germany and the United Kingdom begins after four weeks and eight weeks, respectively; in Switzerland, waiting time begins after three months. *See* OECD, *The Telecommunications Industry: The Challenges of Structural Change* 99, Table 6 (1988).

In essence, the six major countries for which we have a "common" measure all seem to exhibit high levels of service quality. We reach this conclusion with only a limited degree of confidence, however, because of the need for more and better measures and underlying data.[678]

While our analysis is hampered by a lack of comparability, several measures for which data are collected by the FCC collectively indicate a high level of service quality in this country that has risen, on balance, since divestiture.[679] The Commission found that through 1989, "aggregated service quality measures generally have improved or remained above values reported in 1985," although on-time service provisioning for residences has declined slightly.[680] Besides on-time service orders (which were completed by BOCs, as promised, 97.6 percent of the time for residences and 99.0 percent for businesses during 1990), the main categories that are monitored on a regular basis include customer satisfaction levels (94.0 percent or better for all customers), dial tone response (99.0 percent success rate), transmission quality (98.3 percent of objectives met), and the aforementioned call failure rate.[681]

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[678] A single indicator may not adequately capture a country's total quality performance. *See, e.g., Can Europe Untangle Its Telecommunications Mess?*, Business Week, Mar. 31, 1986, at 68-70; *Europe's appalling data networks*, Communications Systems Worldwide, Oct. 1989, at 30 ("a recent survey of the performance of Europe's public data networks indicates that nearly one in four calls fails to get through, mostly because of problems with telecommunications"); *An unlikely trustbuster*, Forbes, Feb. 18, 1991, at 100 ("the Italian government administers one of the world's shoddiest public phone systems, with dilapidated equipment and interminable customer delays"), *David vs. Goliath in the U.K.: The U.K.'s Competitive War: Who is Winning*?, Telephony, Jan. 25, 1988 at 28-40 (during 1987-1988, the British press attacked BT for "out-of-order pay phones, alleged overcharging, and failure to provide reasonable levels of service").

On the other hand, it is claimed that the German telecommunications system has "traditionally neglected the 'surface gloss' of new services in favor of the highest possible quality in basic service." *See Concentrating on new services*, Communications Systems Worldwide, Sept. 1989, at 12. In the United States during the early post-divestiture period, service quality problems surfaced, causing a re-examination by telephone companies and manufacturers in this country of how to improve their performance. *See, e.g., New quality problems trouble telecom industry*, Telephony, Apr. 14, 1986, at 44, 48, 50, 54.

[679] *See FCC Update on Quality of Service for the Bell Operating Companies*, at 20-21 (July 1991) (FCC Quality Update).

[680] *Id.* at 17, 19.

[681] *Id.* at 11-21.

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COUNTRY	% FAILURES PER TOTAL CALLS MADE**			
	YEAR	COMPOSITE	LOCAL ONLY	RANKING
Japan	1985	NA	.05(a)	1
Canada	1989	.4(b)	NA	2
United States	1990	.4–1.1(c)	.4(c)	3
Germany	1984	1.8(d)	.5(d)	4
United Kingdom	1989	1.9(e)	1.1(e)	5
France	1987	2.5(f)	NA	6
Italy	NA	NA	NA	NA

* These countries represent the seven largest among all OECD members plus Singapore based on the most recent GNP or GDP data available.

** Total local and long distance calls made (*i.e.*, excludes international).

(a) Failure rate includes plant defects only.

(b) Results of 1990 survey of Canadian telephone companies.

(c) .4 is intraLATA rate, 1.1 applies to interLATA. BOCs only.

(d) Composite calculated by combining local and long distance blocked calls divided by total calls.

(e) Composite calculated by combining local and long distance blocked calls divided by total calls. Final 1989 local failure rate as determined by British Telecom. Failure rates include defects and congestion.

(f) Failure rate includes successful calls of unsatisfactory quality.

SOURCE: OECD, *Performance Indicators for Public Telecommunications Operators* at 130 (1990); *MESA Rebuttal* at 10; Hong Kong Telecommunications Statistics 1986 at 8, 11 (comparison with NTT); MESA 1990 survey of Canadian telephone companies; FCC, *Update on Quality of Service for the Bell Operating Companies*, July 1991, at 20-21 *(FCC Quality Update)*; *British Telecom Supplementary report 1989*, at 17.

Table 5.21: Call Failure Rates per Total Calls in The United States and Other Large Countries*

D. RECOMMENDED METHODOLOGICAL IMPROVEMENTS

The data and analyses that commenters have developed for this inquiry represent a laudable beginning of the task of comparing the telecommunications systems of different nations. The analytical work that MESA, ETI, Darby, and other commenters have undertaken has greatly contributed to this process. With their participation, some worthwhile bases of comparisons have evolved. Despite this progress, refinements to the various comparisons are still needed. We delineate below the types of methodological changes that should be developed to effect the improvements that we believe are necessary.

1. The Most Meaningful Measures for International Comparisons.

When judiciously employed, international comparisons of infrastructure development can provide useful insights. For example, a superior service quality performance or the greater availability of valuable service capabilities by a major trading partner is important for U.S. telecommunications providers and their customers, since it could affect the international competitiveness of U.S. businesses that rely on telecommunications. Since the deployment of advanced technologies generally enhances quality and service capabilities and in light of the fact that data on technology deployment is generally more available than direct measurements of quality or service capabilities, technology comparisons can also provide useful information.

However, even if it can be convincingly shown that a particular nation is the "leader" in one facet or another of infrastructure modernization, this fact by itself may not be meaningful unless the item at issue is related to what customers need. Network usage is a valuable statistic because it gauges to some degree the network's ability to supply the needs of customers, and to achieve scale or scope economies.[682] Telephone penetration and related measures are important barometers of this nation's progress in meeting its universal service objective, as discussed in Chapter 7; their utility with respect to international comparisons in this area seems to center on their use as measures of comparative development.

Some comparisons belie easy classification. In our analysis, we have chosen to focus on the seven largest countries in the world, based on national income. Within that grouping, there is no consistent leader across the various types of comparisons. As a result, one must attempt to develop weightings. For instance, on the basis of our comparisons (and subject to the caveats discussed above), U.S. telecommunications firms:

- feature one of the most highly developed public telecommunications systems with respect to per-capita telephone penetration and network usage;

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[682] The clarity that network usage statistics bring to investment comparisons is currently limited by the inability to quantify.

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- spend the highest proportion of their average investment per line on modernization; and
- lead others in the deployment of electronic switch technology.
- rank in the middle range in average investment per line;
- currently rank in the middle range, and according to projections, may soon rank in the lower ranges, in deployment of such technologies as digital switches and SS7; and
- trail most of the other large countries in current and projected implementation of ISDN.

Because of the complexities of international comparisons, given the different economies and telecommunications environments of the various countries, to answer completely and accurately the question "How are we doing?" would require a multifaceted, complex response. We can conclude with reasonable confidence that the current state of the U.S. telecommunications network is quite good. There are, however, certain trends about which it is possible to be less sanguine.

Although only limited projections are available,[683] based on the 1994 projections that we have examined, the United States may no longer have a meaningful lead in the deployment of electronic switching through its network and may trail a number of major countries for which data are available in the deployment of digital switches, SS7, and ISDN. Of course, these are only forecasts involving uncertain data. Even if the projections are accurate, this would not mean that the United States would find itself permanently behind; just as others (*e.g.*, France during the 1970s and 1980s) have been able to deploy extensively modern equipment by "leapfrogging" outmoded technologies, the United States, too, could certainly regain its traditional position as a leader in infrastructure development. Nonetheless, with little countervailing data submitted during the course of this lengthy inquiry, we would be less than candid if we failed to recognize the real possibility that this country could be falling behind other countries in deploying certain technologies.

It should also be emphasized that in evaluating the comparisons, "more" is not necessarily better than "less." This is especially true with respect to investment data. A country's investment may be inefficient, and international comparisons may not show this. The appropriate goal should be neither to maximize nor minimize infrastructure investment, but to optimize such expenditures. Indeed, if output measures were more easily obtained, one would presumably consider the most efficient countries those that were able to minimize the resources required to produce any particular level of output.

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[683] For example, our fiber deployment comparisons are hampered by lack of meaningful data.

2. Data for Meaningful Comparisons.

Valuable data sources already exist that permit certain international comparisons, and we have attempted to use them in our analyses. We have relied on the ITU, the OECD, and AT&T's *The World's Telephones* as sources of data for multiple countries, and have also been aided by the FCC's extensive body of statistical reports in our examination of the United States.[684] Our study has also benefitted from the pioneering work performed by the OECD's Science, Technology and Industry Directorate.

Although this is a good beginning, more must be done to improve the analysis. We have identified data shortcomings as we have encountered them in this study.[685] In response, we have adjusted data to make the comparisons more meaningful and believe that we have made progress in this regard. Despite the best efforts of those concerned with these comparisons, however, serious data limitations remain. These center on comparisons of investment and service quality, and are addressed in some detail in Appendix D.

Availability and reliability of data are fundamental concerns of this analysis. As discussed above, some of the needed data are currently found in several sources; however, these statistics are published at different times and, when categories overlap, do not necessarily employ the same methodologies or yield the same results. In some cases, researchers had to perform special studies (for example, the MESA surveys) in the attempt to fill the voids. In others, the information apparently did not exist. The continuing need to collect and compile the range of statistics from multiple sources— some of them *ad hoc*—is not reassuring.

Accordingly, NTIA believes that a more coordinated and comprehensive approach should be adopted in order to generate regularly useful data for international comparisons. We recommend that the ITU and OECD establish a data center in consultation with designated organizations within all participating countries. The objective of the center would be to develop data requirements and common measures that would permit meaningful comparisons of infrastructure on an intercountry basis. Entities, such as AT&T, that are already involved in collecting and disseminating such data should be included from the start in this effort. We also urge the participation of the nascent Data Globe Group Association, comprised of major telecommunications carriers throughout the world whose stated purpose is to collect, assimilate, and disseminate telecommunications-related information globally.[686] In addition, all interested parties should be able to provide inputs into the process. In short, the telecommunications community should build upon what has been begun prior to and during this inquiry in terms of data generation for international comparisons, with the express goal of obtaining more and better data through an improved process.

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[684] In particular, the Common Carrier Bureau's Industry Analysis Division generates many informative reports on a recurring basis that have proven to be useful in this area.

[685] *See* discussion *supra* notes 587-589 and accompanying text.

As part of this effort, we urge policymakers from other countries to designate official organizations to coordinate data generation both within their countries and as representatives to the international data center. Within the United States, the FCC should be the focal point for this country's data development activities. Indeed, the Common Carrier Bureau of the FCC has recently requested public comment on proposed reporting requirements relating to service quality and infrastructure for LECs under price-cap regulation.[687] NTIA will seek to consult with the Bureau, including its Industry Analysis Division, on a regular basis to identify the types of data needed to measure all major elements of the infrastructure. Interested parties should be able to participate in the process, and should be encouraged to provide the data needed to develop meaningful comparisons.

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[686] According to its founders, this non-profit association intends to produce a series of Telecommunications Resource Handbooks containing public information on development, trade, "environment," and prospective government and operator plans that will be sold worldwide.

[687] More specifically, the Bureau seeks comments on its proposed service quality indicators, and data requests relating to access lines, gross capital expenditures, and deployment of switching and transmission technologies. *See Common Carrier Bureau Seeks Comments on Price Cap Service Quality and Infrastructure Monitoring*, 6 FCC Rcd 1621 (1991). *See also Amendment of Part 36 of the Commission's Rules and Establishment of a Joint Board*, Request for Comments, 6 FCC Rcd 4481 (1991).

IV. CONCLUSIONS

The ultimate objective of a nation's telecommunications infrastructure development should be to satisfy current and future user needs effectively and efficiently. Under this standard, international comparisons alone should not be the determining factors in how U.S. telecommunications capabilities evolve, since all countries differ in their current states of development and goals. These comparisons serve useful functions such as educating government and business decision-makers in this country and permitting us to learn from the experiences of others. Conducted properly, these examinations and any concomitant insights that they can confer on infrastructure issues can enhance the ability of U.S. firms to compete in an increasingly global economy.[688]

Our analysis of the seven largest countries confirms the notion, widely expressed in the comments, that the United States is a nation with a well-developed, advanced infrastructure, characterized by a very high access-line density, a robust level of telephone usage, and a heavy emphasis on "modernization." At the same time, the U.S. annual growth rate in public telecommunications investment per line related to modernization during the 1980s, on average, was negative. A definitive ranking of U.S. average public telecommunications investment per line vis-à-vis the other major countries of the world is problematic. It is possible, but subject to challenge. It appears that the United States is neither first nor last among the seven major trading countries of the world in this regard.

The much-debated technology comparisons find the United States currently leading the world in total deployment of electronic switches. This deployment could be matched by several other large countries by 1994. Our analysis regarding fiber optics yielded no useful ordering. France has installed much more SS7 capability, measured by adaptation of central offices, than the United States and other major countries thus far and is expected to maintain its lead into the mid-1990s. Perhaps most striking is the much faster deployment of narrowband ISDN by other large countries relative to the United States. If current trends continue, France, Germany, and Japan will possess 100 percent ISDN coverage at a time (1994) when the BOCs will have converted about half of their equipped access lines.

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[688] For a recent examination of trade and regulatory aspects of telecommunications equipment and services, see *Competitiveness Report, supra* note 184.

The significance of these findings is not clear-cut. With respect to such technologies as digital switching, fiber optic transmission, and SS7, the critical question is whether deployment is occurring at an efficient rate in the United States, not whether this country is "keeping up" with our trading partners. The continued prevalence of monopoly control and centralized government planning for telecommunications in many of these countries creates the real possibility that inefficient levels of investment (whether over- or under-investment) may be taking place. Nevertheless, the ambitious deployment schedules of other countries should cause U.S. firms to evaluate their own plans, and U.S. policy-makers and regulators to reexamine policies that may be hindering the achievement of efficient levels of investment in infrastructure development in this country.

Narrowband ISDN deployment poses another set of issues. The ISDN deployment rate of the United States compared to those of other countries poses a clear contrast in national infrastructure development strategies. It is important to recall that although ISDN requires specialized equipment, both within networks and on customer premises, ISDN defines a set of services as well. The deployment of ISDN services in the United States will be a function of the market—that is, user demand for applications and the availability and desirability of alternative forms of service. Because of our demand-oriented society, only if ISDN services surpass the capabilities of other offerings or reduce costs to users relative to these alternatives will they be commercially successful in this country. Other countries, reflecting the central planning performed by their telecommunications administrations, have adopted narrowband ISDN as a standard. It is unclear whether such differing approaches will cause any compatibility problems or somehow limit the ability of the United States to communicate internationally with minimum disruption. It does appear, however, that these differing approaches will permit a test, on a grand scale, of the utility of narrowband ISDN to users, particularly in light of new standards being developed for Universal Personal Telecommunications (UPT).[689]

There is little doubt that several of our most important trade partners have embarked upon ambitious long-term modernization programs for their telecommunications networks. NTT, the principal Japanese service provider, has inaugurated a 25-year program named "OFL-21" (Optical Fiber Loop for the 21st Century) to build a broadband network that will reach "every school, business, and home" by the year 2015.[690] NTT expects to begin offering in 2005 such "VI&P" (Visual, Intelligent, and

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[689] *See supra* notes 484-485 and accompanying text.

[690] J. Suwinski, "Building The Broadband Infrastructure: A Challenge for U.S. Competitiveness," Remarks presented to the Telecommunications Industry Association, at 3 (Apr. 8, 1991).

Personal) services as high-definition visual communications, voice recognition and voice synthesis capabilities, and portable phones.[691] Under its "Technopolis" economic development program, the Japanese government has helped create "Teletopia" projects involving videotex and interactive television, and built roads with optical fiber ducts and cable boxes pursuant to its "Intelligent Cities" initiative.[692]

The Europeans are also adopting a long-run planning horizon for developing their telecommunications infrastructure. Deutsche Bundespost Telekom plans to offer cable television, ISDN, and other high-technology services in a seven-city trial of fiber-to-the-home during 1991 as part of a major modernization program called "Telekom 2000" for all of reunified Germany.[693] The United Kingdom is undertaking telecommunications-related capital investment at record levels, accounting for seven percent of such expenditures by all private sector companies in the country in 1990.[694] And France—already possessing one of the most advanced networks in the world—has identified telecommunications as its "Great Project" of the 1990s, an undertaking French officials describe as the continuation of a tradition that has resulted in the creation of the Eiffel Tower, TGV trains, the Concorde supersonic airplane, and Ariane rockets.[695]

In terms of service quality, the one common indicator shows each of the seven countries to possess a call completion success rate of 97.5 percent or better. However, there is also independent evidence that seems to suggest that significant quality problems have occurred recently in at least some of these countries, such as Italy, the United Kingdom, and European data networks in general.[696] In the United States, despite one-time events brought about by natural disasters (*e.g.*, the Hinsdale, Illinois, central office fire) or aberrational technical problems (such as the software-induced service disruptions to the

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[691] *See, e.g.*, *Growth forecast for Japanese network*, Communications International, Mar. 1991, at 15; H. Yamaguchi, *A View toward Telecom Services and Networks in the 21st Century*, NTT Review, Mar. 1990, at 12-14.

[692] *See* I. Masser, *Technology and Regional Development Policy: A Review of Japan's Technopolis Programme*, 24 Regional Stud. 41 (1990); Communications Daily, Jan. 15, 1991, at 3.

[693] According to a Telekom official, the modernization program for the "establishment of a new infrastructure in the new eastern states of Germany" will cost over $27 billion and is projected to last seven-to-ten years; there will also be efforts to accelerate the use of "digitization" and fiber optics to assure the "swift evolution of the telecommunications infrastructure in western Germany." *See* Gerd Tenzer, "The strategy of Deutsche Bundespost TELEKOM for FIBER TO THE HOME," Remarks delivered to ComForum Conference at Orlando, Florida (Dec. 10, 1990); Communications Daily, Dec. 11, 1990, at 1-2.

[694] British Telecom, *Annual Review 1990*, at 2, 4.

[695] M. Steckel & M. Fossier, *FRANCE TELECOM: An Insider's Guide* 3 (1990).

[696] *See supra* note 678.

AT&T network in January 1990 and the networks of Bell Atlantic and PacTel in late June and early July 1991), the service quality performance of common carriers has been very good and getting better since divestiture.

As discussed in Chapters 6 and 7, NTIA recommends that U.S. telecommunications policy goals can best be met by reliance on market mechanisms unfettered by government regulation where competition is feasible. It has been the experience of the United States that competition is the preferred approach for major sectors of the telecommunications infrastructure, and it is NTIA's view that the scope of competition can be expanded even further. When government intervention is needed to correct for market failures or imperfections, that intervention should be designed in a way that provides incentives for efficient operation and investment similar to those that would prevail in a competitive market.

Thus, we recommend greater reliance on market forces, allowed to freely operate through government policies that promote competition and deregulation wherever feasible, to choose the basic direction and pace of technological change in telecommunications. We recognize that a market-based environment may create some structural problems, such as inter-industry disputes, a more complex standardization and planning process, and greater difficulties in accumulating the substantial critical mass needed to attract suppliers to a given market. Once fully in place, however, this mechanism would tend to optimize infrastructure capital outlays in an efficient manner that is not otherwise attainable. In this setting, the marketplace would grade the suppliers' performance. This principal reliance on market mechanisms also means that in this country we must be especially careful to ensure that government policies and regulations do not undercut incentives or capabilities for telecommunications firms to make efficient investments in the nation's infrastructure. (For most purposes, we do not have the option of making major "corrective" moves through the issuance of government fiats.) We turn to other policy issues that affect U.S. infrastructure development in the next chapter.

Chapter 6 Government Policy and Infrastructure Development

I. INTRODUCTION

In this chapter, we examine the effect of government regulation on infrastructure development with respect to customer premises equipment, interexchange service, and local exchange service. In describing the U.S. telecommunications infrastructure and its relationship to economic and social development, preceding chapters have surveyed the possibilities and challenges that the infrastructure presents for policymakers. Chapter 3 identified the many ways in which telecommunications can contribute to the well-being of the United States and its citizens. As we have seen, U.S. businesses can harness telecommunications in order to operate more efficiently, better serve their customers, and compete more effectively in a rapidly changing global economy. Social services organizations can use telecommunications to deliver critical services such as education and health care more cheaply, more extensively, and more equitably than is the case today. Ordinary people can rely on telecommunications to enrich their lives through increased opportunities for both work and recreation, as well as the ability to communicate with friends and family more easily and effectively. And millions of disabled Americans can use telecommunications to gain access to economic and social opportunities that many of their fellow citizens take for granted.

Chapter 4 demonstrates further that the domestic telecommunications infrastructure is evolving steadily and substantially. New technologies are being deployed, new capabilities and services are being introduced, and new providers are emerging or becoming established. It is safe to say that the pace of U.S. telecommunications infrastructure development has accelerated over the past thirty years and can be expected to continue to do so in the future. However, to gain some insight into whether this rate of progress is sufficient, we turned Chapter 5 into an international comparative analysis.

The discussion in Chapter 5 indicates that the U.S. telecommunications system compares favorably with those of other major nations, although the significant superiority that we enjoyed in the past is clearly diminishing, at least with respect to some nations. Specifically, our analysis confirms the commonly-held belief that the United States has an advanced telecommunications infrastructure, characterized by a very high access-line density and a robust level of usage. Moreover, among the seven largest nations (in terms of national income), U.S. firms spend the highest proportion of their average annual capital investment per access line on modernizing their networks. On the other hand, while investment in the public telecommunications network continued to grow in the 1980s, the average rate of growth was negative. Further, it appears that U.S. investment per access line lagged behind some, although not all, major nations. Moreover, with respect to the deployment of certain advanced network technologies, the United States trails several major nations now and, according to current projections, will lag behind a somewhat larger number of nations within the next three to five years. It should be noted, however, that international comparisons are difficult due to poor and not comparable data.

NTIA believes that the U.S. telecommunications system of the future must continue to meet the needs of all Americans. Similarly, we have stated that one objective is to promote "efficient" infrastructure investments.[697] We also seek to ensure that the U.S. telecommunications system not only remains secure and reliable, but also continues to be a source of economic, social, cultural, and political empowerment for American citizens. In particular, we recognize that, for almost sixty years, the lodestars for U.S. telecommunications policymakers have been both the development of technically and economically efficient communications services and the opportunity for all citizens to avail themselves of those services. These guiding principles are set forth in Section 1 of the Communications Act:

> to make available, so far as possible, to all the people of the United States a rapid, efficient, Nation-wide, and world-wide wire and radio communication service with adequate facilities at reasonable charges.[698]

The soundest way to determine efficient and fair infrastructure development is for government to create a process that can be relied upon to produce the appropriate level of development.[699] In this regard, we agree with the many commenters that argue that, to the greatest extent feasible, infrastructure development should achieved via the workings of a competitive marketplace.[700] While the general benefits of competition are well-known,[701] its importance with respect to infrastructure development is that it offers telecommunications providers a powerful set of decentralized, independent, and market-driven incentives to make efficient investment decisions. Simply put, customers in a competitive market will identify and penalize inefficient under-and over-investments by taking their business from inefficient firms to their rivals.

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[697] *See supra* at 87. *See also* Comments of California at 2; Comments of Rochester Telephone Corp. at 25.

[698] 47 U.S.C. § 151 (1988).

For this reason, a principal focus of this chapter is an examination of the ways that efficient investment in the infrastructure can be realized through increased competition in telecommunications markets.[702] A striking feature of the U.S. telecommunications industry is the extent to which government itself has established restrictions, or outright prohibitions, on the development of competition among firms operating in different parts of the industry. In a dynamic, "high tech" area such as telecommunications, government policies ideally should promote competition by facilitating the free flow of resources—capital, technology, expertise—across industry sectors so that firms can adjust their operations to take advantage of rapidly changing marketplace and technological conditions, and ultimately better serve their customers. In contrast, the telecommunications landscape in this country is divided into a series of economic fiefdoms by government-established "walls" specifically designed to prevent such free flows of

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[699] This problem is of more than academic interest. America has a fundamental interest in efficient infrastructure development. For example, investing too much in our telecommunications system would waste scarce resources that could be directed towards other social needs or objectives. On the other hand, "[f]ailing to exploit the potential of telecommunications technology could be as myopic as overinvesting in it." Schwartz, *U.S. Telecommunications Policy: Demand Dictates Supply* at 10 (1991). Put another way, if adequate telecommunications services and capabilities are not in place where and when needed, the U.S. will not realize the many benefits that telecommunications can produce.

[700] *See, e.g.*, Comments of Rochester Telephone Corp. at 10-11; Comments of TIA at 4; Comments of Northern Telecom at iv; Comments of Prodigy Services Co. at 1; Comments of Eastman Kodak Co. at 7-8; Comments of AT&T at 23-24.

[701] Economic theory indicates, for example, that competition forces prices towards costs, with concomitant increases in consumer welfare. *See, e.g.*, Brock and Evans, *Creamskimming*, in *Breaking Up Bell: Essays on Industrial Organization and Regulation*, 61, 62-63 (D. Evans ed. 1983). At the same time, pressure from rivals compels firms to minimize their production costs, thus ensuring that the resulting output is produced with the least use of society's scarce resources. *See, e.g.*, *MTS and WATS Market Structure*, 81 FCC 2d 177, 202 (1980); Comments of California at 9. Finally, competition forces producers to become more sensitive to consumer wants and needs, thus tending to provide a wider range of goods and services than prevails in non-competitive markets. *See, e.g.*, *Brock*, *supra* note 355, at 304-305.

[702] Where full competition is not feasible (at least in the short term), we also believe that it is important for regulators to adopt approaches that replicate, to the extent possible, the incentives for efficient operation and investment that characterize competitive markets.

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resources and the competition that might otherwise develop among firms in adjacent sectors.

While the original purpose of at least some of these restrictions may have been to promote competition (by prohibiting firms with market power in one industry sector from extending that power into other areas), their principal effect now in many cases is to protect incumbent firms from competition. Moreover, while in the past it may have been thought that the costs imposed were not very large (because, for example, different services required different types of technologies), recent developments that increase the power and versatility of communications and computing technologies are increasingly making these restrictions technologically obsolete and economically costly.

Despite these problems with government-imposed obstacles to competition in the telecommunications industry, these barriers are not easy to change. Incumbent firms, while often eager to expand into another company's "turf," are considerably less willing to accept increased entry into their own markets—and, if forced to choose between the two alternatives, will often accept restrictions on their own ability to compete in new areas in return for continued protection from competition in their own markets. Thus, the political/policy momentum necessary to effect changes in the *status quo* in these areas has often been lacking. Fortunately, for the reasons discussed *infra*, technological forces in telecommunications are so rapidly eroding the basis for government-imposed entry barriers and other restrictions on competition that the need for change is becoming more widely appreciated by policy makers and the inevitability of change more widely accepted by incumbents (on both sides of these "walls").[703] This creates a situation in which there is a much greater possibility of revising the rules of the game in a more pro-competitive direction.

II. CUSTOMER PREMISES EQUIPMENT

The potential benefits of competition in telecommunications markets are confirmed by the results of the introduction of competition into the CPE market. In the 15 years since that market was fully opened to competitive entry,[704] there has been an explosion in the variety of CPE available to users. For the average consumer, this development is, perhaps, epitomized by the humble telephone. When telephone carriers provided such equipment on a monopoly basis, consumer could generally choose between a standard, black telephone that delivered unadorned voice service, and a limited range of colored instruments.[705] Today, that same consumer can select from a wide array of CPE with numerous colors, sizes, shapes, and designs. As importantly, telephones for home use routinely now include a variety of additional features, such as speed dialing of selected numbers, speaker phones, and hold functions, that greatly increase the ease of telephone use.

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[703] As will be discussed below, similar movements towards increased competition have been taking place in other nations. *See, e.g., infra* notes 713, 965, and 968.

[704] Although courts first established a right to connect customer-provided equipment to the public switched network in 1956, *see Hush-a-Phone Corp. v. United States*, 238 F.2d 266 (D.C. Cir. 1956), that right was (continued...)

Choice is also the norm now with respect to other CPE. In 1988, for example, the typical business user could select from some 1349 different kinds of CPE, an increases of more than 58 percent from 1975.[706] Moreover, while the variety of CPE available to consumers was expanding, the cost of that equipment has generally been declining.[707]

Consumers have also benefitted substantially from the services available via CPE. Cordless telephones give their users added mobility, thus ensuring that making and answering telephone calls will not interfere with their important daily activities. Answering machines allow consumers to receive calls at any hour of day, while pursuing business or pleasure elsewhere. With a facsimile machine and a standard telephone line, an individual can send a document within minutes to any location in the world that is

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[704] (...continued from preceeding page)
not finally vindicated until the FCC adopted the Part 68 registration program in the mid-1970s. *See Interstate and Foreign Message Telephone Service*, 58 FCC 2d 736 (1976), *aff'd sub nom. North Carolina Util. Comm'n v. FCC*, 552 F.2d 1036 (4th Cir.), *cert. denied*, 434 U.S. 874 (1977); *Interstate and Foreign Message Telephone Service*, 56 FCC 2d 593 (1975), *recon.*, 57 FCC 2d 1216, 59 FCC 2d 83, 59 FCC 2d 716 (1976). In 1980, the FCC deregulated provision of CPE and required common carriers to unbundle their CPE from their tariffed service offerings. *See Amendment of Section 64.702 of the Commission's Rules and Regulations (Second Computer Inquiry)*, 77 FCC 2d 384, *recon.*, 84 FCC 2d 50 (1980), *further recon.*, 88 FCC 2d 512 (1981), *aff'd sub nom. Computer and Communications Indus. Ass'n v. FCC*, 693 F.2d 198 (D.C. Cir. 1982), *cert. denied*, 461 U.S. 938 (1984). A transition was established for "embedded" CPE (*i.e.*, equipment then on customer premises), which ended for the BOCs at divestiture when their CPE was transferred to AT&T and removed from regulation.

[705] *See Brock*, *supra* note 355, at 305.

[706] *See* NATA, IDCMA and TIA, *The Post-Divestiture U.S. Telecommunications Manufacturing Industry: The Benefits of Competition* at 2 (Mar. 1990) (*CPE Report*) (submitted as Attach. A to Comments of TIA) (citing *Telephony's Directory and Buyer's Guide*).

[707] *See id.* at 4 (between 1977 and 1989, the average annual increase in the price of communications equipment was roughly half the annual increase in prices for the economy as a whole, indicating that the price of that equipment declined about 50 percent, in real terms, over that period). *See also* Comments of NATA at 9 (citing absolute price declines in three types of CPE (key systems, modems, and PBXs) between 1984 and 1988).

similarly equipped. Interactive voice response systems allow customers to access account records using a Touchtone keypad for account balance inquiries, paying bills, and the like.[708] A PBX can enable a community of users within a building or a campus to operate their own telephone company with respect to intrabuilding or intracampus calling.

Given the robustly competitive state of the CPE market, the principal focus for policymakers should be to preserve the gains that have been made to date. NTIA therefore recommends, for example, that the FCC maintain its rule that bars common carriers from bundling CPE with their tariffed service offering.[709] Additionally, any proposal to amend or eliminate the manufacturing restriction in the AT&T Consent Decree[710] should contain safeguards to ensure that the BOCs do not engage in anticompetitive conduct should they be allowed to engage in manufacturing. NTIA notes that the FCC's nonstructural safeguards that now apply to BOC provision (as opposed to manufacture) of CPE in conjunction with network services appear to be working well. We are therefore confident that effective safeguards can be adopted to deter anticompetitive conduct where a BOC is able to manufacture CPE.[711]

III. INTEREXCHANGE INFRASTRUCTURE

The introduction and growth of competition in the interexchange services market have produced benefits similar to those realized in the competitive CPE market. Just over ten years after the FCC removed the final regulatory barriers to competitive provision of interstate long distance services,[712] there are now, according to a recent FCC estimate,

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[708] *See CPE Report, supra* note 706, at 2.

[709] *See* Reply Comments of NTIA in CC Docket No. 90-132, at 32-36 (filed Sep.18, 1990) (citing 47 C.F.R. § 64.702(e) (1990)). *See also* Comments of IDCMA at 8 n.5.

[710] *See infra* notes 742-745 and accompanying text.

[711] While the concerns about BOC entry into manufacturing of CPE are not identical in all particulars to those relevant to BOC provision of CPE, they are similar in their underlying premises—that the BOCs can use their control over bottleneck local exchange facilities to engage in anticompetitive discrimination or cross-subsidization. *See Furnishing of Customer Premises Equipment by the Bell Operating Telephone Companies and the Independent Telephone Companies*, 2 FCC Rcd 143, *recon.*, 3 FCC Rcd 22 (1987), *aff'd sub nom. Illinois Bell Tel. Co. v. FCC*, 883 F.2d 104 (D.C. Cir. 1989).

[712] *See MTS and WATS Market Structure*, 81 FCC 2d 177 (1980). The FCC first permitted alternative provision of interstate common carrier services in 1971, when it authorized firms to construct microwave systems in order to offer unswitched, private line services in competition with the Bell System. *See Specialized Common Carrier Services*, 29 FCC 2d 870, *recon.*, 31 FCC 2d 1106 (1971), *aff'd sub nom. Washington Util. and Transp. Comm'n v. FCC*, 513 F.2d 1142 (9th Cir.), *cert. denied*, 423 U.S. 836 (1975). One year

(continued...)

some 448 long distance carriers providing a wide range of services, serving arrangements, and pricing options.[713] This expansion in the providers and service options available to most consumers, coupled with pricing reforms by the FCC (especially in the changes assessed to IXCs for access to LEC networks), has led to sharp rate reductions for those services. The price of ordinary switched long distance telephone service for the average residential user, for example, has declined nearly 45 percent since the beginning of 1984,[714] or about 60 percent in "real" (*i.e.*, inflation-adjusted) dollars.

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[712] (...continued from preceeding page)
later, the FCC allowed competitive provision of private line services via satellite. *See Domestic Communications—Satellite Facilities*, 35 FCC 2d 844 (1972), *aff'd sub nom. Network Project v. FCC*, 511 F.2d 786 (D.C. Cir. 1975). However, the growth of interexchange services competition was spurred most dramatically by court decisions overruling the FCC's attempts to prevent MCI from offering switched interstate services. *See MCI Telecommunications Corp. v. FCC*, 580 F.2d 590 (D.C. Cir.), *cert. denied*, 439 U.S. 980 (1978); *MCI Telecommunications Corp. v. FCC*, 561 F.2d 365 (D.C. Cir. 1977), *cert. denied*, 434 U.S. 1040 (1978).

[713] *See Long Distance Report, supra* note 479, at 6. There has been a movement towards increased competition in the provision of long distance service in other nations as well. Some nations have fully opened the long distance market to competition. For instance, in 1985, Japan radically changed the structure of its state-owned telephone industry, abolishing the service monopoly of Nippon Telegraph and Telephone (NTT), the company that had been responsible for domestic telephone service, opening the market to new competitors, and privatizing NTT. Since that time, a number of new common carriers have been established, including three long-distance carriers. *See* InfoCom Research, Inc., *Information & Communications in Japan* 179-84 (1991) (*Information & Communications in Japan*). The United Kingdom has recently decided to abolish the current duopoly policy, under which only British Telecom and Mercury Communications Ltd. have been licensed to provide basic telecommunications services over fixed links, and instead open fully the domestic marketplace to competition. *See* Department of Trade and Industry, *Competition and Choice: Telecommunications Policy for the 1990s* 1 (Nov. 1990) (*Duopoly Review*).

Other nations have allowed competition on a more limited basis. In Germany, the Federal Ministry of Posts and Telecommunications (MPT) has opened significant parts of the telecommunications market to competition, although the Deutsche Bundespost Telekom still retains a monopoly over switched voice services. However, the Monopoly Commission recently recommended that the long-distance market be opened up to competing network providers, and the MPT has decided to license private satellite carriers to provide switched voice service for traffic between the territories of the former Federal Republic of Germany and German Democratic Republic (GDR) and within the former GDR. German Monopolies Commission, Press Release at 5 (June 13, 1991); Federal Ministry of Posts and Telecommunications, *Development of Telecommunications Policy in Germany: A Status Report* 4 (Apr. 30, 1991); Federal Ministry of Posts and Telecommunications, *Principles for Granting Licenses for the Telephone Service Via Satellite in and with the New Federal States* 2, 5 (Mar. 27, 1991).

Several other nations—such as Korea and Australia—are moving from a monopoly to a duopoly market structure for long distance service. *See* B. Choi, *Policy Reform of the Korean Telecommunications Market* 5 (1991); R. Poi, *Competing in Korea*, Communications Week International, Apr. 1, 1991, at 1; Australia Ministry for Transport and Communications, *Microeconomic Reform: Progress Telecommunications* 2 (Nov. 1990) (*Australia Reform*).

[714] *See Telephone Trends, supra* note 30, at 12.

As expanded competition in the interexchange market has generated significant benefits for consumers, it also has dramatically spurred infrastructure development.[715] As AT&T notes, the years since divestiture have witnessed the construction of several new nationwide telecommunications systems.[716] For example, US Sprint has constructed what it calls the nation's first, all-fiber long distance network. In August 1990, MCI announced a plan to have an all-digital network in place by the end of 1991 and to write off nearly $500 million of its embedded network equipment as part of its accelerated deployment of the technology needed to achieve that goal.[717] Moreover, since divestiture, AT&T has invested more than six billion dollars to upgrade its own interstate network,[718] by increasing digital and fiber deployment more rapidly than probably would have occurred in the absence of competition.[719] Finally, the National Telecommunications Network, a consortium of five separate companies, operates an all-fiber optic network of some 18,000 route miles serving all states east of the Mississippi River, and a majority of the states to the west. As a result, there are now at least four nationwide, fiber-based interexchange carrier networks serving the United States and numerous regional networks.

The bulk of this investment appears to be committed to deploying state-of-the-art technologies. For example, IXCs recognized early the value of investment in fiber development and they have shown a strong commitment to fiber deployment.[720] During the last five years alone, in a survey of selected interexchange carriers, the FCC has estimated growth from 455,000 fiber miles to over 2.1 million fiber miles.[721] As noted above, US Sprint states that its nationwide network is composed entirely of fiber transmission facilities. IXCs have led the deployment of advanced signalling technology. AT&T developed and began deploying common channel signalling in its network in 1976. In recent years, other interexchange carriers have moved quickly to deploy SS7, a more advanced version of the earlier technology, in their networks. And with such investments in advanced technology, these carriers have advertised their network improvements and competed on the basis of quality improvements.

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[715] In the words of FCC Chairman Alfred Sikes:

> Few would dispute the fact that, but for the spur of competition, the United States would not have seen fiber optics technology ··· move from the test laboratory to a nationwide network of more than 175,000 kilometers of installed, lightwave technology.

Remarks of Alfred C. Sikes, Chairman, FCC, Before the Financial World Communications Conference, at 3 (Dec. 4, 1989).

[716] Comments of AT&T at 14.

[717] *See* Hsu, *MCI Speeds Up Its Drive To Modernize Equipment,* Wash. Post, Aug. 22, 1990, at F1.

[718] *See id. See also* Comments of AT&T at 14.

[719] In 1987, AT&T projected that 95 percent of its network would be digital by the year 2010. As a result of the massive investments made since 1984, however, AT&T's network was 95 percent digital in mid 1989, and is virtually 100 percent digital today. *See* Statement of Kenneth L. Garrett, Senior Vice President—Network Services, AT&T, before the Subcomm. on Telecommunication and Finance of the House Comm. on Energy and Commerce, 102d Cong., 1st Sess., at 3 (Oct. 1, 1991).

[720] Corning has noted that its first "commercially significant" order for fiber optic cable came from MCI.

[721] *Fiber Deployment Update, supra* note 392, at 11.

With the recognition that interexchange competition continues to drive useful investment in advanced technologies, we believe that regulatory obstacles to the efficient functioning of this market should be removed, with only such safeguards retained as are necessary to guard against the potential for anticompetitive actions. Thus, NTIA has supported FCC efforts to encourage vigorous competition in this market and to adjust regulatory oversight of carriers when their market power with respect to provision of particular services has diminished.[722]

The FCC has already begun to alter its oversight of the one remaining federally-regulated interexchange carrier—AT&T. In April 1989, the FCC replaced rate of return regulation for AT&T with a form of "price cap" regulation.[723] This approach is an important step forward, for it will both give AT&T greater flexibility to respond to its interexchange rivals and protect AT&T's subscribers from excessive long distance rates. As importantly, unlike the case under rate of return regulation, adoption of a price cap scheme should reduce FCC scrutiny of AT&T's investment decisions,[724] and thereby increase AT&T's willingness to make the necessary network investment to keep pace with its competitors.

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[722] We note that September 1, 1991, was the expiration date of a provision in the AT&T Consent Decree that requires that:

> the charges for delivery or receipt of traffic of the same type between [BOC] end offices and facilities of interexchange carriers within an exchange area, or within reasonable subzones of an exchange area, shall be equal, per unit of traffic delivered or received, for all interexchange carriers.

Modification of Final Judgment, App. B, Sec. B(2), *United States v. AT&T*, 552 F. Supp. at 233. Termination of this provision will likely mean that the FCC will have to change the way in which interstate access charges for the facilities involved are now set, which could have significant implications for the competitive state of the interexchange services market. The FCC is now grappling with these difficult issues. *See MTS and WATS Market Structure, Transport Rate Structure and Pricing*, CC Docket Nos. 78-72, Phase 1, 91-213, FCC 91-250 (released Aug. 1, 1991). We believe that the public interest will be served if the FCC ensures that the new access rates reflect underlying costs, and not an effort to preserve interexchange competition artificially.

[723] *See Policy and Rules Concerning Rates for Dominant Carriers*, 4 FCC Rcd 2873 (1989), *recon.*, 6 FCC Rcd 665 (1991). Rate of return regulation attempts to control regulated rates by constraining the firms' profits. In contrast, a price cap approach seeks to control prices, rather than profits, by limiting increases in regulated rates according to a formula that reflects the costs of providing regulated services and productivity gains.

The FCC recently acted to relax its regulation of some of AT&T's interstate services in other ways.[725] Specifically, the FCC further streamlined regulation for most of AT&T's business services, as well as those services not now subject to price cap regulation. The FCC also allowed AT&T to offer certain common carrier services on a carrier contract basis. NTIA supports such actions because we believe that they can further enhance infrastructure development in interexchange networks, by both AT&T and its competitors.

IV. LOCAL EXCHANGE INFRASTRUCTURE

Although competition has burgeoned in many telecommunications markets (such as CPE and interexchange services), with beneficial effects for the U.S. infrastructure, it has not yet taken hold in one major segment of the telecommunications industry—the provision of local exchange services. In the typical local exchange market, the lion's share of such services are still provided by a single dominant firm, subject to extensive government regulation as to its business practices and protected from competition by government barriers to entry. As a result of this situation, users receive an array of local services, and associated prices, determined largely by the LECs and heavily influenced by regulatory policies. Similarly, the infrastructure built to support these services is often heavily influenced as much by regulatory policy as by technological developments and customer demand.

In addition to government oversight of the pricing and investment decisions of the LECs, there is also "structural" regulation of LEC activities.[726] For example, fear of the LECs' ability to use their monopoly control to harm either competitors in related fields or ratepayers has resulted in various types of government restrictions on LEC activity in some unregulated fields, even when such activity would otherwise be in the public interest. Such restrictions also can have effects on the development of the nation's infrastructure.

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[724] *See infra* notes 899-901 and accompanying text.

[725] *See Regulatory Reform for the Long-Distance Marketplace Adopted*, CC Docket No. 90-132, FCC 91-251 (released Sept. 16, 1991).

[726] Of course, in the case of the BOCs, a major source of such structural regulation has been the line of business restrictions contained in the AT&T Consent Decree. *See infra* notes 729-800 and accompanying text.

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Nevertheless, competition is now developing for some local exchange services in some geographic markets. The emergence of such competition presents several important policy issues. First, it may call for changes in the way that incumbent service providers are currently regulated. For example, it warrants reexamination and, if appropriate, removal of restrictions that now limit the markets that incumbent firms may enter. The growth of competition also emphasizes the need to reform the regulatory mechanisms presently used to oversee incumbent firms' pricing and investment decisions, so that those firms will have an opportunity to respond effectively to competitive entry. Moreover, the appearance of competition for some local exchange services raises the broader questions of whether regulators should authorize competitive provision of all local exchange services and, if so, how that should be implemented. We examine these issues below.

A. Removing Barriers to Entry by Local Exchange Carriers into Related Telecommunications Markets

In this section, NTIA considers two of the most prominent barriers to LEC entry into other telecommunications markets—the line of business restrictions contained in the AT&T Consent Decree[727] and the cable-telephone company crossownership rules contained in Section 613(b) of the Cable Act.[728] In so doing, we recognize that NTIA and, in some instances, the Administration have taken positions on these issues. Where appropriate, we will identify those positions and the policy rationale for them. However, the focus of our discussion will be the impact that these restrictions may have on infrastructure development.

1. AT&T Consent Decree

In addition to mandating the divestiture by AT&T of the 22 BOCs and their reorganization into seven Regional Holding Companies, the AT&T Consent Decree (Decree) limited the range of services that could be provided by the BOCs. Specifically, the BOCs were barred from manufacturing telecommunications equipment and CPE, and from providing information services and interLATA services.[729] The Decree also precluded the BOCs from providing "any other product or service, ... that is not a natural monopoly service actually regulated by tariff" (the "catch-all restriction").[730]

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[727] *See* Modification of Final Judgment, Section II(D), *United States v. AT&T*, 552 F. Supp. at 227-228.

[728] 47 U.S.C. § 533(b) (1988). The crossownership provisions in the 1984 Act generally codify restrictions first adopted by the FCC in 1970. *See* 47 C.F.R. §§ 63.54-63.58 (1990).

In February 1987, the Department of Justice recommended that the U.S. district court with jurisdiction over the Decree (the "Decree court") modify the interLATA services restriction and remove the other three line of business restrictions.[731] The Department of Justice concluded that implementation of the Decree and "subsequent technological, economic and regulatory changes have sufficiently reduced the competitive danger of BOC entry into any of these fields" to obviate the need for the restrictions.[732] It also suggested that the restrictions "themselves limit competition and impose efficiency losses in terms of foregone services or higher costs."[733]

In October 1987, the Decree court decided to maintain the manufacturing and interLATA service restrictions,[734] while lifting the catch-all restriction[735] and modifying the information services restriction.[736] On appeal, the reviewing court, while upholding the

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[729] The Decree states that the ban applies to "interexchange" services. *See* Modification of Final Judgment, Section II(D)(1), *United States v. AT&T*, 552 F. Supp. at 227. It was soon discovered, however, the term "exchange," as used in the Decree, had a completely different meaning from the way it was used in traditional regulatory parlance. To avoid confusion, AT&T suggested, and the court accepted, that the term "local access and transport area" (LATA) be used for Decree purposes in place of "exchange." *See United States v. Western Elec. Co., Inc.*, 569 F. Supp. 990, 993 n.9 (D.D.C. 1983).

[730] Modification of Final Judgment, Section II(D)(3), *United States v. AT&T*, 552 F. Supp. at 228.

[731] *See* Report and Recommendations of the United States Concerning the Line of Business Restrictions Imposed on the Bell Operating Companies by the Modification of Final Judgment at 6-7, *United States v. Western Elec. Co., Inc.*, 673 F. Supp. 525 (D.D.C. 1987), *aff'd in part and rev'd and remanded in part*, 900 F.2d 283 (D.C. Cir. 1990) (*First Triennial Review*). The Department of Justice recommended that the BOCs be allowed to offer interLATA services entirely outside of their regions. It also recommended that, if a BOC could show that "all regulatory barriers to entry ... have been removed in particular exchange areas within its region, that BOC also should be allowed to provide [interLATA] service among such competitive exchange areas or among one or more such exchange areas and any points outside of that BOC's region." *Id.* at 7. However, the Department of Justice subsequently withdrew this proposal on the grounds that implementing such a scheme "presented insuperable practical difficulties." *First Triennial Review*, 673 F. Supp. at 543.

[732] Report and Recommendations of the United States Concerning the Line of Business Restrictions Imposed on the Bell Operating Companies by the Modification of Final Judgment at 6-7, *United States v. Western Elec. Co., Inc.*, 673 F. Supp. 525 (D.D.C. 1987).

[733] *Id.* at 5.

[734] *See First Triennial Review*, 673 F. Supp. at 540-562.

[735] *See id.* at 597-599.

[736] *See id.* at 587-597.

Decree court's ruling in many respects,[737] reversed the Decree court's decision not to remove the information services restriction.[738] The court of appeals concluded that because the Department of Justice's recommendation to lift the restriction was not opposed by the other parties to the Decree, AT&T and the BOCs, the Decree court should have reviewed that recommendation under the "public interest" standard implicit in Section VII of the Decree,[739] rather than the more restrictive test prescribed by Section VIII(C) for contested requests to modify the Decree's restrictions.[740] Accordingly, the appellate court remanded with directions for the Decree court to review the need to continue the information services restriction under the more lenient "public interest" standard. On July 25, 1991, the Decree court issued an opinion and order lifting the information services restriction.[741]

While the line of business restrictions have sparked controversy and litigation virtually from the moment of divesture on January 1, 1984, the disputes surrounding the restrictions have focused, for the most part, on their implications for competition, U.S. trade and competitiveness, and telecommunications service prices. Drawing upon the

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[737] *See United States v. Western Elec. Co., Inc.*, 900 F.2d 283, 300-305, 309-310 (D.C. Cir. 1990).

[738] *See id.* at 305-308.

[739] Section VII provides that:

> Jurisdiction is retained by this Court for the purpose of enabling any of the parties to the [Decree], or, after the reorganization specified in section I, a BOC to apply to this Court at any time for such further orders or directions as may be necessary or appropriate ... for the modification of any of the provisions hereof . . . .

Modification of Final Judgment, Section VII, *United States v. AT&T*, 552 F. Supp. at 231. When the parties to an antitrust consent decree consent to its modification, a reviewing court must approve the change if "the resulting array of rights and liabilities comports with the 'public interest.'" *United States v. Western Elec. Co., Inc.*, 900 F.2d 283, 305 (D.C. Cir. 1990) (citations omitted). Although the phrase "public interest" does not appear in Section VII, the court of appeals nonetheless ruled that the "public interest" standard for reviewing uncontested modifications of consent decrees was "incorporated in Section VII's general provision for modification of the [AT&T] decree." *Id.*

[740] *See United States v. Western Elec. Co., Inc.*, 900 F.2d at 305-307. Section VIII(C) states that:

> The restrictions imposed upon the separated BOCs by virtue of section II(D) shall be removed upon a showing by the petitioning BOC that there is no substantial possibility that it could use its monopoly power to impede competition in the market it seeks to enter.

Modification of Final Judgment, Section VIII(C), *United States v. AT&T*, 552 F. Supp. at 231.

[741] *United States v. Western Elec. Co., Inc.*, Civ. Action No. 82-0192 (HHG) (D.D.C. July 25, 1991) (*Information Services Ruling*). Although the court stayed the effectiveness of its order until completion of the appellate process, the United States Court of Appeals for the District of Columbia Circuit vacated the stay on October 7, 1991. *See United States v. Western Elec. Co., Inc.*, No. 91-5263 (D.C. Cir. Oct. 7, 1991).

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record generated in this proceeding, we will primarily assess the effect of these restrictions on the development of the U.S. telecommunications infrastructure.

a. The Manufacturing Restriction

Section II(D)(2) of the Decree bars the BOCs from manufacturing "telecommunications equipment"[742] and customer premises equipment (CPE).[743] In 1987, the Decree court defined the term "manufacturing" to include not only fabrication, but also earlier stages of the production process, such as product-specific design and development.[744] As a result of this decision, the BOCs' activities with respect to telecommunications equipment and CPE are limited to basic research and development of generic product specifications.[745]

In March 1989, NTIA issued a report that examined the court's interpretation of the manufacturing restriction and recommended that modification (or elimination) of that provision would be in the public interest.[746] Recently, NTIA and the Department of Justice, on behalf of the Administration, and the FCC testified in favor of legislation that would remove the manufacturing restriction, subject to effective competitive safeguards.[747] In both instances, NTIA expressed concern that the restriction, as interpreted by the court, was hampering research and development (R&D) within the United States, "not only for the [BOCs] themselves, but also for other entities desiring to work with the [BOCs] to manufacture telecommunications equipment."[748] We further noted the extent to which the manufacturing restriction could impede the ability of the BOCs and other U.S. firms to compete in global telecommunications equipment markets.[749]

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[742] "'Telecommunications equipment' means equipment, other than customer premises equipment, used by a carrier to provide telecommunications services." Modification of Final Judgment, Section IV(N), *United States v. AT&T,* 552 F. Supp. at 229.

[743] "'Customer Premises Equipment' means equipment employed on the premises of a person (other than a carrier) to originate, route, or terminate telecommunications, but does not include equipment used to multiplex, maintain, or terminate access lines." *Id.* Section IV(E), *United States v. AT&T,* 552 F. Supp. at 228.

[744] *See United States v. Western Elec. Co., Inc.,* 675 F.Supp. 655 (D.D.C. 1987), *aff'd,* 894 F.2d 1387 (D.C.Cir. 1990) (*Manufacturing Order*).

[745] *See* Comments of Southwestern Bell Corp. at 45. In contrast, in other nations, telephone companies often engage in various activities through affiliated companies that would be deemed "manufacturing" in the United States. For instance, in Canada, the nation's largest telephone company, Bell Canada, is a wholly-owned subsidiary of BCE Inc., a group of companies that also includes Northern Telecom, a major telecommunications equipment manufacturer, and Bell Northern Research, Canada's largest private industrial R&D organization. Similarly, British Columbia Telephone Company, Canada's second largest telephone company, is affiliated with Microtel Ltd. and Microtel Pacific Research. *See* Communications Canada, *Canadian Telecommunications: An Overview of the Canadian Telecommunications Carriage Industry* 14, 16 (1988) (*Canadian Telecommunications*). In Japan, affiliates of NTT, the largest telephone company, are engaged in such activities as the design of electronic devices (NTT Electronics Technology Co.), basic R&D in communications technologies (Advanced Telecommunications Research Institute International), design and provision of software and hardware for PC communications (NTT PC Communications Inc.), design of value added network systems (Nippon Information and Communication Corp.), development of software for PBX use (Business Communication System Engineering Co.), and development of data communications systems (NTT Data Communications System Corp.). *See Information & Communications in Japan, supra* note 713, at 156-57. With respect to R&D in particular, we are aware of no developed nation that restricts the telecommunications-related research and development activities of its telephone companies to the extent that occurs in the United States.

We also believe, and the record in this proceeding confirms, that the restriction hampers development of the U.S. telecommunications infrastructure. As discussed in Chapter 4, the capabilities and services that comprise the nation's telecommunications system are based, to a large degree, upon technology-intensive products that are combined to form public and private networks. To the extent that government regulation impedes development of those products, it hinders development and deployment of the networks and services built upon them. For example, many believe that the absence of a low-cost terminal has hampered growth of mass market information services in the United States.[750] If the BOCs were allowed to manufacture equipment, they might be able to develop such a terminal, which could make information services economically feasible for more consumers.[751] In a similar vein, removing the manufacturing restriction could promote development of central office-based or customer premises equipment that would permit more widespread and more error-free use of telecommunications services by disabled Americans. For this reason, a number of spokespersons for disabled Americans have endorsed a lifting of the manufacturing restriction.[752]

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[746] National Telecommunications and Information Administration, U.S. Dept. of Commerce, *The Bell Company Manufacturing Restriction and the Provision of Information Services* (Mar. 1989) (*Manufacturing Report*).

[747] *See The Telecommunications Equipment Research and Manufacturing Competition Act of 1991: Hearings on S.173 Before the Subcomm. on Communications of the Senate Comm. on Commerce, Science and Transportation*, 102d Cong., 1st Sess. 40-42 (1991) (prepared statement of Janice Obuchowski, Administrator of NTIA) (Manufacturing Testimony). *See also id.* at 45-48 (prepared statement of James F. Rill, Assistant Attorney General, Antitrust Division, U.S. Department of Justice); *id.* at 35-38 (prepared statement of Alfred C. Sikes, Chairman, FCC).

[748] Manufacturing Testimony, *supra* note 747, at 40. *See also Manufacturing Report, supra* note 746, at 23-33.

[749] *See* Manufacturing Testimony, *supra* note 747, at 41; *Manufacturing Report, supra* note 746, at 21-22, 35.

[750] *See, e.g.*, Comments of GECS at 6; Reply Comments of AHTUC at 20.

[751] *See* Comments of Herbert Dordick at 15.

The evidence suggests that the manufacturing restriction slows development of new telecommunications products in a number of ways. First, and fundamentally, the Decree court's interpretation of the term "manufacturing" is based on the view that manufacturing is a linear process composed of a series of discrete stages.[753] Accordingly, the theory goes, a firm can be excluded from one or more of those stages without making the entire manufacturing process more costly or more time consuming. In fact, however, telecommunications manufacturing is "a highly fluid process, without clear distinction between steps, and with considerable interaction, overlay, and feedback among them."[754] Under these conditions, expeditious, efficient development of new telecommunications products would be facilitated by close and continuous coordination between the BOCs and their equipment suppliers.[755] It is precisely this sort of interaction that the court's current reading of the term "manufacturing" prevents.[756]

Second, in an age of computer-controlled switching equipment, it is technically possible for LECs and other service providers to expand the range of services available to their customers simply by upgrading or modifying the software that controls their switches.[757] However, the manufacturing restriction, as currently interpreted by the Decree court, precludes the BOCs from doing so. As a result, the BOCs must request such software changes from the switch manufacturer. They have experienced delays of up to two years in obtaining new software for switches that they already own. In the meantime, BOC customers are denied the services that a software change could make available.

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[752] *See, e.g.*, Statement of Frank G. Bowe, Hofstra Univ. at NTIA/APT Field Hearing, Newark, New Jersey, May 11, 1990 (attached to Reply Comments of APT).

[753] *See Manufacturing Report, supra* note 746, at 8-10; Comments of DEC at 14.

[754] *Manufacturing Report, supra* note 746, at 9. *See also* Comments of DEC at 14-15; Comments of BellSouth Corp. at 23 and App. E at 11-12; Comments of Northern Telecom at 80-81.

[755] *See* Comments of DEC at 15-17; Comments of BellSouth Corp., App. E at 23; Comments of Verilink Corp. at 7-8; Comments of Northern Telecom at 79-80.

[756] *See, e.g.*, Comments of Bell Atlantic at 7; Comments of NYNEX Corp. at 90-91; Comments of Verilink Corp. at 7.

[757] *See Telecommunications Equipment Research and Manufacturing Competition Act: Hearings on S.1981 Before the Subcomm. on Communications of the Senate Comm. on Commerce, Science, and Transportation*, 100th Cong., 2d Sess. 27 (1990) (Statement of John L. Clendenin, Chairman and CEO, BellSouth).

Third, a primary purpose of telecommunications R&D is the development and introduction of new products.[758] Thus, a government restriction that reduces firms' incentives to invest in R&D threatens to impair "both the pace at which innovations are being brought to the market and the overall cost of that process."[759] The restriction flatly prohibits the BOCs from engaging in a wide variety of R&D. Basically, as soon as R&D becomes focused on product-related design and development, the BOC must cease its efforts. The result is that while the BOCs have broad latitude in conducting research and development for network services and network design, they have very limited ability to conduct research and development on the equipment that implements that design or makes the services possible.[760] This is a highly artificial distinction that, the record indicates, has limited the BOCs' incentives to invest in R&D, both directly and indirectly (through a chilling effect on R&D efforts that are, or could become, close to the prohibited line).[761]

Finally, efficient development of telecommunications products is further impeded by lingering uncertainties about the precise scope of the manufacturing restriction. For example, although the court concluded that the restriction barred the BOCs from engaging in product-specific design and development, it provided little guidance on the nature and scope of those precluded activities. When one BOC submitted to the court a list of its ongoing engineering and software development activities with a request for a ruling as to which were permissible, the court declined to rule, but noted that some of those activities "may be forbidden."[762]

Pacific Telesis has discontinued development on no fewer than six different products because of uncertainties about whether those activities are permissible under the manufacturing restriction.[763] Additionally, prior to divestiture, a Pacific Bell employee developed a device called a "punching block," which could improve provision of alarm services.[764] Although the employee produced the design for the device, it was manufactured by an unaffiliated firm. In Pacific Bell's view, had that work been done after divestiture (and under the Decree court's current definition of "manufacturing," it "would have resulted in discipline for the employee at best and a contempt citation for the company and the employee at worst."[765]

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[758] *See* Manufacturing Testimony, *supra* note 747, at 41; *Manufacturing Report, supra* note 746, at 34.

[759] Manufacturing Testimony, *supra* note 747, at 40.

[760] *See Manufacturing Order*, 675 F. Supp. at 667.

[761] *See Manufacturing Report, supra* note 746, at 23-33; Comments of BellSouth Corp., App. E at 9-10; Comments of NYNEX Corp. at 90; Comments of Verilink Corp. at 6; Comments of Direct Dialogue Council #5, Urbandale, Iowa at 2.

[762] *See* Comments of Bell Atlantic at 7 (citing *United States v. Western Elec. Co., Inc.*, Civ. Action No. 82-0192, slip op. at 1-2 (D.D.C. Feb. 8, 1988)). The record also indicates that the continuing uncertainties about the precise scope of that restriction deters the BOCs from working with equipment suppliers in developing new equipment and service applications. *See, e.g.*, Comments of NYNEX Corp. at 90-91; Comments of DEC at 17-19.

[763] *See* Comments of PacTel in Docket No. 61267-6267 (NTIA's request for public comment on manufacturing restriction), at 3-5 (filed Jan. 31, 1989).

Additionally, persistent uncertainties about the precise scope of the manufacturing restriction has created situations where a BOC's "laboratory microscopes are frequently dwarfed by legal magnifying glasses trying to define that fine line between what is and isn't permitted under the [AT&T Consent Decree]."[766] US West states that it has experienced projects where the ratio of lawyer time to engineering time has approached 10 to 1. It also reports of one case in which the lawyers spent six months before allowing an engineer to develop a prototype of a piece of equipment, and the engineer completed her work in three weeks.[767]

For all of these reasons, removing the manufacturing restriction will have salutary effects on U.S. infrastructure development. We are, of course, aware of those who argue that eliminating the restriction may deter infrastructure development because it will reduce competition in the manufacture and sale of telecommunications equipment and CPE.[768] Some parties contend that allowing the BOCs to manufacture equipment would adversely affect competition by reviving the BOCs' incentives to procure their equipment from affiliated manufacturers, rather than dealing with competing suppliers on the basis of price and quality.[769] They also allege that the BOCs could harm competing equipment manufacturers through cross-subsidization or by giving BOC-affiliated manufacturers discriminatory access to network information.

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[764] If trouble develops in an alarm service system, the bunching block can remove the malfunctioning equipment or facility from service, without interrupting the total system.

[765] *The Telecommunications Equipment Research and Manufacturing Competition Act of 1991: Hearings on S.173 Before the Subcomm. on Communications of the Senate Comm. on Commerce, Science and Transportation,* 102d Cong., 1st Sess. 74 (1991) (prepared statement of Sam Ginn, Chairman and Chief Executive Officer, PacTel).

[766] *See Telecommunications Equipment Research and Manufacturing Competition Act: Hearings on S.1981 Before the Subcomm. on Communications of the Senate Comm. on Commerce, Science, and Transportation,* 100th Cong., 2d Sess. 216 (1990) (Statement of Winston J. Wade, President, US West Advanced Technologies).

[767] *See id.* at 212-213.

[768] *See, e.g.,* Comments of TIA at 5-9; Comments of IDCMA at 18-19; Comments of NATA at 8-10.

[769] *See, e.g.,* Comments of IDCMA at 19.

While NTIA is cognizant of such concerns, we are convinced that they are either overstated or can be addressed by safeguards short of barring the BOCs from the manufacturing business. For example, the steady shift among regulators from rate of return regulation to "incentive" regulation[770] should reduce the BOCs' incentive to "self-deal" with affiliated manufacturers because, under incentive regulation, the BOCs will be unable, or less able, to pass their inflated equipment costs on to ratepayers, as was alleged to be the case under rate of return regulation. Moreover, as the Department of Justice found when it last examined the manufacturing restriction in 1987, both the divestiture itself and the growth of an extensive non-BOC market for telecommunications equipment limit the potential effect that BOC procurement decisions can have on telecommunications equipment markets.[771] As a result, even if self-dealing were to occur, we do not believe that it would have a significant adverse effect upon competition in those markets.

As for concerns about cross-subsidization and discriminatory release of network information, we believe that regulatory safeguards exist, or can readily be adopted, to minimize the potential for such anticompetitive conduct. The FCC has prescribed cost allocation and accounting rules designed to prohibit carriers such as the BOCs from recovering costs associated with unregulated services in their provision of regulated products and services.[772] The FCC has also adopted rules that require carriers to disclose publicly information concerning network design changes to equipment manufacturers and other parties on a timely and non-discriminatory basis.[773] These safeguards (modified as necessary) will be sufficient to ensure that BOC participation in manufacturing will not harm competition in telecommunications equipment markets.

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[770] *See infra* notes 890-893 and accompanying text.

[771] *See* Report and Recommendations of the United States Concerning the Line of Business Restrictions Imposed on the Bell Operating Companies by the Modification of Final Judgment at 161-162, *United States v. Western Elec. Co., Inc.*, 673 F. Supp. 525 (D.D.C. 1987). We note that this assessment was based on the actions of an individual BOC. The competitive effects of a manufacturing joint venture between two or more BOCs would be more serious.

[772] *See Separation of Costs of Regulated Telephone Service from Costs of Nonregulated Activities*, 2 FCC Rcd 1298, *recon.*, 2 FCC 6283 (1987), *further recon.*, 3 FCC Rcd 6701 (1988), *aff'd sub nom. Southwestern Bell Corp. v. FCC*, 896 F.2d 1378 (D.C. Cir. 1990). If these regulations do not apply to BOC manufacturing operations, they could, and should, be modified to so apply.

[773] *See* 47 C.F.R. § 64.702(d)(2) (1990) (as clarified in *Computer and Business Equipment Mfrs. Ass'n*, 93 FCC 2d 1226 (1983)).

b. Information Services Restriction

NTIA supports the Decree court's recent decision to lift the restriction specified in Section II(D)(2) of the Decree, prohibiting the BOCs from providing information services.[774] Elimination of this restriction will enhance the growth potential of new and innovative information services by increasing the BOCs' incentives to invest in the infrastructure needed to make such services available.[775] The inclusion in the information services market of the BOCs, with their access to the small businesses and individuals that comprise the bulk of the nation's telecommunications users, will permit U.S. telecommunications facilities to develop to the extent that best serves the American public.[776] The record in this proceeding supports that conclusion.

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[774] *See Information Services Ruling, United States v. Western Elec. Co., Inc.*, Civ. Action No. 82-0192 (HHG) (D.D.C. July 25, 1991). As defined in the Decree,

> "information service" means the offering of a capability for generating, acquiring, storing, transforming, processing, retrieving, utilizing, or making available information which may be conveyed via telecommunications, except that such service does not any use of any such capability for the management, control, or operation of a telecommunications system or the management of a telecommunications service.

Modification of Final Judgment, Section IV(J), *United States v. Western Elec. Co., Inc.*, 552 F. Supp. at 229.

[775] NTIA has expressed this concern on several occasions. *See, e.g.*, Notice, 55 Fed. Reg. at 810, para. 85; *Information Services Report, supra* note 374, at i-v; National Telecommunications and Information Administration, U.S. Dept. of Commerce, *Issues in Domestic Telecommunications: Directions for National Policy*, NTIA Special Pub. 85-16, at 77-82, 177-178 (July 1985) (*Domestic Study*).

[776] Telephone companies are involved in the provision of information services to varying degrees in other nations. As discussed more fully below, *infra* note 784, France's state-owned PTT has actively promoted the development of the French Minitel system. In Canada, the nation's largest telephone company, Bell Canada, offers a videotex service called "Alex." In Germany, the Deutsche Bundespost Telekom acts as a "mechanical intermediary" to Bildschirmtext (Btx), a network that provides access to a wide variety of one-way information services and two-way interactive services.

In Japan, NTT, the nation's largest domestic telephone company, offers a variety of enhanced and information services, both directly and through affiliates. For instance, NTT offers "off-talk" communications services, using unoccupied telephone lines to provide subscribers with the one-way transmission of audio material from information providers, and it has created a subsidiary to develop information services and programming for this service. NTT also offers audiotex and provides access to "Dial Q" information services (equivalent to 900 numbers in the United States), providing billing services for approximately 900 information providers. Through affiliated companies, NTT offers "CAPTAIN" (a videotex service similar to the French Minitel system) and "SuperCAPTAIN" (a form of video-on-demand service for closed user groups). N. Koike, *Cable Television and Telephone Companies: Towards Residential Broadband Communications Services in the United States and Japan* 113, 127-29 (1990) (*Koike*). With respect to CAPTAIN, NTT provides both gateway services to numerous information providers and also has offered its own information services on a trial basis, such as "CAPTAIN Town Pages," a form of electronic yellow pages. NTT also offers "Hello Dial," a service in which NTT operators (or recorded messages) provide information to callers about particular services or businesses that have registered with NTT.

By one measure, the U.S. information services sector is thriving. There are now literally hundreds of information service providers within the United States,[777] which provide access to more than 3,300 different databases.[778] Further, demand for information services is projected to increase by some 20 percent annually through 1995.[779] The healthy growth of this sector is reflected by the preeminence of the domestic information services industry internationally. Not only have American firms developed the majority of the more than 4,000 databases now available worldwide,[780] but U.S. information services have consistently maintained a positive trade balance.[781]

Viewed from another perspective, however, the information services picture is somewhat less rosy. To a large degree, the fruits of the U.S. information services industry are available to large business users and consumers who can afford, and have the technical sophistication to use, personal computers and modems.[782] For the majority of American households without such equipment,[783] the availability of information services, particularly videotex services, is much more limited, both in absolute terms and as compared to other nations.[784] NTIA recognizes that the slow development of consumer-oriented information services has not been due entirely to the information services restriction.[785]

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[777] *See, e.g.*, Comments of CompuServe Inc. at 9.

[778] *See* Comments of BT Tymnet, Inc. at 9.

[779] *1991 Industrial Outlook*, *supra* note 371, at 27-2.

[780] *See id.*

[781] *See id.* at 27-1; Comments of CompuServe Inc. at 13.

[782] *See Information Services Report*, *supra* note 374, at 100; Comments of Southwestern Bell Corp. at 37; Comments of GECS at 3-6. *See also* Comments of VIA at 3 (over 95 percent of users gain access to videotex services via personal computers).

[783] Roughly 24 percent of the nation's 94 million households (22.6 million households) are now equipped with personal computers. *See 1991 Industrial Outlook*, *supra* note 371, at 28-8 to 28-9. It is estimated that one-third of those homes may also own modems. *See* Comments of CompuServe Inc. at 6 n.5.

[784] *See, e.g.*, *Information Services Clarification*, 714 F. Supp. at 5. The French Minitel system is frequently held up as a model for the U.S. to follow in developing "mass market" information services. However, the extent of, and bases for, the success of Minitel are subjects of considerable dispute. *Compare MESA Rebuttal*, *supra* note 553, at 8-9 and Comments of France Telecom, Inc. at 7-9 *with ETI Study*, *supra* note 550, at 14-16; Comments of CompuServe Inc. at 13-14; and Comments of MCI Telecommunications Corp. at 15-20. *See also Information Services Ruling*, *United States v. Western Elec. Co., Inc.*, Civ. Action No. 82-0192 (HHG) (D.D.C. July 25, 1991), slip op. at 52. It is clear, however, that the growth of the Minitel system to date has been driven substantially by decisions by the French government and the state-owned PTT to push Minitel forward by a number of means, including the free distribution of Minitel terminals. We believe that industry-driven initiatives are preferable to such government-directed efforts.

[785] *See, e.g.*, *First Triennial Review*, 673 F. Supp. at 590 and notes 291-293 (slow growth of information services may be due to insufficient consumer demand); Comments of VIA at 4 (need to presubscribe before using an information service is a barrier to widespread use); Reply Comments of AHTUC at 20 (primary (continued...)

However, elimination of the restriction increases the likelihood that the BOCs' participation will contribute to the development of a vigorous market for information services available to all Americans.

Elimination of the information services restriction may also now speed the introduction of other services and capabilities into the domestic telecommunications system. For example, the attempts of several BOCs to deploy a network management service that would enable customers to manage and configure leased transmission facilities in either real time or on a predetermined basis, were limited by claims that the services violate the information services restriction.[786] Introduction of such services can now proceed as market demand warrants. Although the Decree court has previously allowed the BOCs to offer an intelligent network database for 800 service, various features that would make that database more useful to consumers, which also were challenged as information services,[787] can now be offered.

Removal of the information services restriction should permit improved infrastructure development in other ways. Many network technologies, such as SS7, ISDN, and electronic switching, can be used to provide both basic services and information services. The growth of the information services market, which we believe could be substantially stimulated for at least certain market segments by BOC participation, should generate increased demand for these advanced network capabilities, enabling the BOCs to cost-justify more widespread or more rapid deployment of new network technologies. These new technologies would therefore be in place to make new features and services available to consumers. As importantly, such technologies will also be used by competing information service and other telecommunications service providers to expand the range of services available to consumers or to furnish existing services more efficiently.

Thus, the Decree court's elimination of the information services restriction will remove an important impediment to the introduction of services and capabilities that enhance the usefulness and performance of the U.S. telecommunications infrastructure. Although we recognize that BOC provision of information services raises some potential for anticompetitive conduct, this can be addressed effectively by competitive safeguards short of barring seven large, experienced firms from that important market. The FCC has

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[785] (...continued from preceeding page)
limitation on the availability of information services is the lack of low-cost terminal equipment); Comments of GECS at 4-6 (same).

[786] *See* Comments of NYNEX Corp. at 87-88.

[787] *See id.* at 88-89.

adopted such safeguards—namely accounting controls and open network architecture—to govern BOC provision of "enhanced services," which are substantially similar to information services.[788] NTIA will continue to work with the FCC to make sure that effective safeguards are in place to prevent anticompetitive conduct by the BOCs.

c. InterLATA Services Restriction

Section II(D)(1) of the Decree also bars the BOCs from offering interLATA services. Alleged anticompetitive activity by the unified Bell System in the interexchange market was a principal focus of the antitrust action brought by the Department of Justice and of the structural remedies agreed to by the parties and adopted by the court. Included among these remedies were the separation of AT&T's long distance operations from the BOCs' local exchange networks and the Decree's equal access requirements. Those provisions contributed substantially to the growth of competition in interLATA services in the 1980s and, in so doing, have promoted the development of the U.S. telecommunications infrastructure by unleashing forces that have compelled the major interLATA carriers to continually modernize and upgrade their networks.[789]

On the other hand, several commenters argue that the Decree court's application of the interLATA services restriction in other areas may hinder the introduction of new services and capabilities into the domestic telecommunications system. In 1989, for example, the court ruled that the restriction precluded Bell Atlantic from centralizing its information services gateway in one of its five Pennsylvania LATAs.[790] The immediate effect of the court's decision was to require Bell Atlantic to install a gateway processor in each of its LATAs if it wished to offer on a region-wide basis the gateway functionalities that the court has allowed it to provide.[791]

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[788] *See Amendment of Section 64.702 of the Commission's Rules and Regulations (Third Computer Inquiry)*, 104 FCC 2d 958 (1986), *recon.*, 2 FCC Rcd 3035 (1987), *further recon.*, 3 FCC Rcd 1135 (1988), *vacated and remanded sub nom. California v. FCC*, 905 F.2d 1217 (9th Cir. 1990). Although the *California* court overturned the FCC's decision to replace structural separation with non-structural accounting safeguards, the FCC has proposed to reinstate such safeguards. NTIA has supported this proposal. *See* Comments of NTIA in CC Docket No. 90-623, at 8-13 (filed Mar. 8, 1991). While NTIA favored reinstating the former accounting safeguards, we also supported FCC initiatives to improve them in several specific respects. *See id.* at 12-13.

[789] *See supra* notes 715-721 and accompanying text.

[790] *See United States v. Western Elec. Co., Inc.*, 1989-1 Trade Cas. (CCH) para. 68,400 (D.D.C. Jan. 24, 1989), *aff'd*, 907 F.2d 160 (D.C.Cir. 1990). Bell Atlantic's plan was to locate a "protocol agile packet assembler-disassembler" (PAP) in each of the five LATAs and a central gateway processor in the Philadelphia LATA. A customer seeking to use Bell Atlantic's gateway would dial a local telephone number to reach the PAP in his LATA. The PAP would determine the characteristics of the customer's terminal, then transmit the call to the processor for performance of the necessary gateway functions. After the customer instructed the processor as to the information service he wished to access, the processor would instruct the PAP to complete the call.

(continued...)

This network design both increases the cost of providing gateway functionalities[792] and imposes on the BOCs costs that are typically not borne by competing providers of gateway services.[793] Most importantly, given the uncertain demand for such services, the increased costs frequently mean that gateway services are not made available in some areas.[794]

Comparable concerns are raised by the court's interpretations of the interLATA restriction with respect to SS7. In July 1990, the court denied requests for a declaratory ruling or, alternatively, for a waiver that would have permitted US West to interconnect its SS7 network with those of the interexchange carriers at a centralized location.[795] As was the case with respect to gateway services, the court's decision means that, in order to provide SS7 interconnection throughout their regions, the BOCs must install an SS7 node within each LATA. According to the BOCs, this decision means several hundreds of

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790 (...continued from preceeding page)

Although Bell Atlantic planned to connect the five PAPs to the central processor via its own "official services" network, the court noted that its decision would have been the same even if Bell Atlantic had procured the interLATA transmission facilities connecting the PAPs and the processor from an IXC. *See id.* at para. 60,203 n.14.

[791] We note that the court ruled on a motion by Bell Atlantic for a declaratory ruling that its gateway architecture was consistent with the Decree. The court's decision therefore does not preclude Bell Atlantic or any other BOC from requesting a waiver of the interLATA restriction for the identical architecture. In this regard, the federal court of appeals decision upholding the Decree court's ruling noted that, if that ruling made it prohibitively expensive for the BOCs to deploy a gateway services region-wide, the BOCs would have "a powerful argument for a waiver from the terms of the decree." *United States v. Western Elec. Co., Inc.*, 907 F.2d at 164-65.

[792] Bell Atlantic asserts that each gateway processor costs about $500,000. *See* Comments of Bell Atlantic at 11 n.26. *See also* Comments of NYNEX Corp. at 92 and n.** (NYNEX can deploy its gateway service throughout its region with only two processors and at about one-fourth the cost of installing a processor in each LATA).

[793] A number of the larger information service providers, such as GEnie, CompuServe, and Quantum Computer Services, operate their on-line services on a centralized basis. Prodigy offers service through several small regional processors that are tied to a central host computer. *See* Comments of BellSouth Corp., App. E at 14.

[794] For example, after the court's decision, Bell Atlantic canceled plans to offer its gateway services throughout Pennsylvania and decided to provide service only in the Philadelphia LATA. *See* Comments of Bell Atlantic at 12. Similarly, prior to the court's ruling, BellSouth considered making its information services gateway available in 20 metropolitan areas. Its deployment plans have since been scaled back to, at most, six cities. *See* Comments of BellSouth Corp., App. E at 15.

[795] *See United States v. Western Elec. Co., Inc.*, 131 F.R.D. 647 (D.D.C. 1990), *appeal pending* (*SS7 Order*).

millions of dollars in additional costs;[796] it also means that, in some cases, that SS7 might not be deployed at all.[797] If that should occur, the public would be denied the efficiencies in call set up and other network functions that SS7 permits.[798]

These decisions are troubling because of their potential adverse effect on infrastructure development. When a BOC plans to introduce a new service or capability, it is likely that demand will often not be sufficient to justify the expense of providing customer access to that service or capability in each of that BOCs LATA. In such a case, a reasonable deployment strategy would be to offer access on a centralized basis at first, and add additional access points as demand warrants. To the extent that the court's decisions preclude such a strategy, they hamper efficient deployment of products, services, and capabilities that could enhance the nation's telecommunications system.

We recognize, of course, that, although a particular deployment strategy may be more efficient for the firm involved, it may raise the potential for anticompetitive behavior that could harm competitors and users. In determining whether the firm should be allowed to go ahead with its deployment plan, the critical question is whether the potential efficiency gains for the firm outweigh the potential welfare losses for society as a whole. In the gateway case, the potential competitive harms threatened by centralized provision of gateway services are not readily apparent. Thus, the public interest would have been served by allowing Bell Atlantic to implement its proposed gateway architecture.

We also conclude that consumers would benefit if the BOCs are allowed to deploy SS7 in the most efficient manner possible, which in certain circumstances could be on a centralized basis. SS7 facilitates efficient set up and transmission of telephone calls, and also makes possible a wide variety of new services.[799] These services are not widely provided now and, by limiting SS7 deployment, the Decree court is limiting the potential for provision of these services to the public in the future. Thus, in an attempt to prevent merely potential anticompetitive conduct, the court is directly shaping the BOCs' networks and indirectly affecting the facilities and services of their customers and competitors in ways that may be impeding the efficient development of an advanced telecommunications infrastructure.[800]

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[796] *See* Comments of Bell Atlantic at 13. US West has estimated that it will cost $60 million initially and $6 million annually to provide SS7 interconnection in each of its LATAs. *See SS7 Order*, 131 F.R.D. at 650 n.7.

[797] *See* Memorandum in Support of US West Motion for Declaratory Ruling or, In the Alternative For Waiver of the Decree at 11-12, *United States v. Western Elec. Co., Inc.*, 131 F.R.D. 647 (D.D.C. 1990) (if US West cannot deploy SS7 on a centralized basis, it may not be economical to deploy it at all).

[798] For a discussion of the benefits of SS7, see *supra* notes 460-463 and accompanying text.

[799] *See* Comments of Bell Atlantic at 12. Such services include call forwarding, call tracing, or automatic number identification (commonly known as "Caller ID." Deployment of SS7 will also improve provision of advanced 800 service. *See Provision of Access for 800 Service*, 4 FCC Rcd 2824, 2825 (1989).

2. Cable-Telephone Company Infrastructure Development[801]

One of the most controversial policy issues discussed in the Notice involves the role of LECs in providing video services.[802] As noted above, Section 613(b) of the Cable Act, and related FCC regulations, prohibit telephone companies from providing video programming within their local service areas.[803] This restriction has direct and visible effects on ordinary Americans, and also illustrates the increasing technological confluence of two traditionally separate wings of U.S. communications—mass media and telephony. Two of the most common, most needed, and most used pieces of electronic equipment in U.S. homes are the television and the telephone.[804] Most U.S. homes now receive their video programming through cable systems,[805] although the most popular sources of programming on cable systems remain the local television broadcast stations that are retransmitted to subscribers as part of "basic" cable service.[806] As noted above, cable operators are increasingly deploying advanced cable systems, both to offer an expanding array of video programming, and to perform trials of their systems for two-way, point-to-point communications.[807]

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[800] We recognize that the direct cost to US West of the court's SS7 ruling, while substantial, is relatively low. Although $60 million is a large amount in absolute terms, it represents about 3 percent of US West's projected annual capital investment of $2 billion. *See* Comments of US West at 12. Moreover, as the court noted, US West (and presumably other BOCs) would likely be able to recover the additional costs of SS7 deployment in the rates it charges to the interexchange carriers. *See SS7 Order,* 131 F.R.D. at 650 n.7. However, the direct costs of the court's decision do not reflect the opportunity costs to the public associated with the resulting delay in the deployment of new services.

[801] This section and other parts of this report addressing telephone company entry into cable television are being issued under the supervision of Thomas J. Sugrue, Deputy Assistant Secretary and Deputy Administrator of NTIA. Assistant Secretary Janice Obuchowski currently is recused from participating in the discussion of this particular issue.

[802] In considering this issue, it may be useful to examine the practices of other nations with respect to the role of telephone companies in the provision of cable television service. While such international comparisons have inherent limitations because of the differing regulatory framework, history, industry structure, and social characteristics of each nation, it is interesting to note that several of the countries surveyed permit a greater degree of telephone company participation in cable than the United States. Moreover, in the two countries where telephone company participation in cable appears to be effectively precluded (Japan and Canada), such restrictions stem from government policy rather than law, so that there is greater room for more flexible application, if circumstances warrant. For further discussion of the policies of other nations in this area, see Appendix E.

[803] However, both the Cable Act and the FCC's rules contain an exemption that allows a telephone company to offer telephone service and video programming in "rural" areas, as defined by the FCC. *See* 47 U.S.C. § 533(b)(3) (1988); 47 C.F.R. § 63.58 (1990). NTIA has supported redefinition of a "rural" area, in order to provide more options to rural viewers in receiving video services. *See* Statement of William Maher, Associate Administrator, Office of Policy Analysis and Development, NTIA before the Subcomm. on Government Information, Justice, and Agriculture of the House Comm. on Government Operations, 101st Cong., 2d Sess., at 5-6 (Feb. 7, 1990).

[804] The radio, of course, is also vitally important in meeting the mass media communications needs of the American public.

Conversely, LECs, which are deploying high capacity fiber optic cable within their public switched networks, hold out the promise of soon being technically able to transport video signals—including television programming—to American homes. LECs contend that removal of the so-called cable-telco crossownership restrictions would provide the necessary incentives for them to develop their public networks with switched broadband capabilities, which could carry a wide variety of voice, data, and video services to the home.[808] In the Notice, we asked a series of questions to gather more information on the purported benefits of a switched broadband network, and then focused on the issue of whether LECs should be permitted to offer video programming.

a. *Economies of Scope in Integrated Provision of Voice, Data, and Video Services.*

NTIA first requested comment on the conditions under which LECs would deploy integrated broadband networks. We noted that some argue that it is more efficient to deliver voice, data, and video services on an integrated basis, *i.e.*, that there are economies of scope in the transmission of voice, data, and video over the same facility.[809] We then asked parties to submit information on the nature and size of such economies.

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[805] More than 58 percent of all U.S. television households now subscribe to cable television. *See* Broadcasting, July 15, 1991, at 41.

[806] *See* Comments of NCTA in MM Docket No. 90-4, at 14-15 (filed Apr. 6, 1990).

[807] *See supra* note 394 and *infra* notes 963-966 and accompanying text. Similar experimentation has been taking place abroad, by telephone companies working alone or in association with cable operators. For further discussion, see Appendix E.

[808] *See* Notice, 55 Fed. Reg. at 811, para. 95 n.116.

[809] *See id.* at 811, para. 93. "the term 'economies of scope' refers to situations in which it is less expensive to provide two or more services jointly rather than separately." Panzar, *The Continuing Role for Franchise Monopoly in Rural Telephony* at 4 n.*** (1987) (*Panzar*) (submitted as App. D to Comments of TDS).

Several LECs indicate that the potential economies of scope may be substantial. BellSouth asserts that, because a broadband system "as the bandwidth capacity to carry both high speed data and video services," and since "telephony, high speed data, and video all share the same transport medium in an integrated switched broadband network, an economy of scope will exist for each of these service capabilities."[810] BellSouth also states that scope economies are likely to arise from the sharing of capital costs and expenses, marketing costs, research and development, and billing and accounting functions among the three types of services carried.[811]

GTE contends that "an integrated switched broadband network would permit substantial economies of scope ... by permitting a far larger number of products and services ... to be provided over the integrated facility."[812] It notes that its broadband trial in Cerritos, California, is intended to explore the benefits of such integration.[813] Finally, USTA submits a study by Neal Stolleman that finds economies of scope in the joint provision of narrowband and broadband services over a switched broadband network.[814] Specifically, the study finds that for video service penetration levels between 30 and 100 percent, the cost of a LEC-provided integrated broadband network was between $500 and $150 per subscriber less, respectively, than the total cost of a LEC-provided narrowband network and a cable-provided switched broadband network.[815]

On the other hand, Continental Cablevision proffers an analysis by Hatfield Associates that takes a skeptical view of the potential economies of scope associated with integrated provision of voice, data, and video. One of Hatfield's fundamental assertions is that

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[810] Comments of BellSouth Corp., App. F at 8.

[811] *See id.*, App. F at 7, 8.

[812] Comments of GTE Service Corp., App. A at 37.

[813] *See id.*, App. A at 37-38. In its most recent report to the FCC, GTE notes that "[t]he integration of voice, data, and video signals through a common transmission system was a highlight" of the Cerritos project in 1990. However, the report does not indicate whether this integrated transmission of voice, data, and video, though technically feasible, is also characterized by economies of scope. *See* GTE California Inc., *1990 Report on Cerritos* (Apr. 1, 1991).

[814] *See* Stolleman, *Economies of Scope in the Provision of Narrowband and Switched Broadband Services: Preliminary Evidence* (submitted as App. 2 to Comments of USTA). Stolleman's work critiques earlier studies that suggest provision of switched video service by cable systems would cost less per subscriber than LEC provision of the same service. *See* Reed and Sirbu, *Integrated Broadband Networks: The Role of the Cable Companies* (presented at Telecommunications Policy Research Conference, Airlie, Virginia (1989)); Reed and Sirbu, *An Engineering and Policy Analysis of Fiber Introduction into the Residential Subscriber Loop* (Nov. 1987).

[815] *See* Stolleman, *Economies of Scope in the Provision of Narrowband and Switched Broadband Services: Preliminary Evidence* 8 (submitted as App. 2 to Comments of USTA).

"although the LECs tend to treat the economic feasibility of an integrated broadband network as a *fait accompli*, ... [its future] is clouded by major technical, economic, and market uncertainties of a fundamental nature."[816] Hatfield contends that, while it is possible to transmit voice, data, and video over a single facility, such integration can also impose penalties because of the wide differences in the requirements for the three services in terms of, for example, the amount of delay and noise that can be tolerated, or the amount of holding time involved.[817] Because of these differences, a network architecture that is optimal for voice traffic may not be optimal for either traditional data or video traffic.[818] When that is the case, Hatfield concludes, trying to combine all three types of traffic in an integrated transmission system could create "diseconomies [that] may well overshadow any purported economies of scope."[819]

Moreover, a study by Johnson and Reed estimates that the cost of an integrated broadband network exceeds "the combined cost of separate narrowband and broadband networks that would offer the same services."[820] Based on this finding, they conclude that "if telephone companies enter the video market during the 1990s, they will do so by building cable television networks separate from their telephone networks."[821] However, Johnson and Reed's assessment of the costs of broadband networks has been criticized on a number of grounds,[822] including claims that the network architecture used to develop their cost estimates was based upon outdated information and that their exclusive focus on switched "on-demand" video as the only new residential service that would be provided on an integrated broadband network.

The debate over the efficiencies associated with integrated transmission of voice, data, and video thus is not conclusive.[823] In our view, such integration does appear to present

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[816] Hatfield Associates, Inc., *The Integrated Broadband Network of the Future: Separating Fact from Wishful Thinking* at 4 (Apr. 1990) (submitted as an Attachment to Comments of Continental Cablevision, Inc.).

[817] *See id.* at 5-7.

[818] *See id.* at 6-7.

[819] *See id.* at 11.

[820] Johnson and Reed, *Residential Broadband Services by Telephone Companies?: Technology, Economics, and Public Policy*, R-3906-MF/RL, at vi (Rand Corp. June 1990).

[821] *Id.*

[822] *See* National Economic Research Associates, Inc., *The Technology and Economics of Providing Video Services by Fiber Optic Networks: A Response to Johnson and Reed* (July 20, 1990).

[823] One party infers the absence of economies of scope in joint transmission of voice, data, and video transmissions from the fact that, where telephone companies are able to offer both telephone service and video programming, they generally do not construct integrated transmission systems. *See* Comments of NCTA at 30-32 and n.69.

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design and engineering issues that will have to be carefully handled if potential economies of scope are to be realized. Nevertheless, there do not appear to be insurmountable technical barriers to resolving these issues. For example, as discussed in Chapter 4, in both domestic and international fora considerable progress has been made on establishing broadband ISDN standards and on addressing other technical issues associated with the implementation of high capacity, integrated digital networks. Moreover, as discussed in Chapter 5, telecommunications policymakers in other countries have apparently concluded that integrated broadband networks are both technically feasible and economically desirable. For example, the Japanese Ministry of Posts and Telecommunications recently concluded that "the early development of broadband ISDN ... [will be] essential for the communications network infrastructure of the 21st century."[824]

Perhaps more importantly from a public policy perspective, the fact that controversy exists over the extent of possible scope economies does not justify government prohibiting a firm from discovering in the marketplace the efficiencies it could realize from an integrated network. Indeed, it is precisely in those areas where there are substantial differences of opinion among industry participants on the direction in which technology will drive the marketplace that government, as a general matter, should not be intervening to favor one approach over another. Rather, government-imposed barriers to investment in new technological approaches should be carefully avoided in the absence of clear evidence of market failure or other strong public policy rationale. We recognize, of course, that there are strong differences of opinion (reflected in the robust debate in this record) on whether the current prohibitions on telephone company provision of video services constitute such a barrier to investment or, if so, whether there are marketplace conditions that might nevertheless justify government intervention. It is to these questions that we now turn.

b. LEC Provision of Programming

A focal point of the debate over the role of LECs in providing video services has been whether they should be permitted to provide video programming, either as originators or producers of programming or as packagers of such programming, like traditional cable operators.[825] We specifically requested comment on the question of what effect the present prohibition on LEC provision of video programming is having, or will in the future have, on LEC incentives to deploy integrated broadband networks.

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[824] MPT News, June 17, 1991 (reporting on results of MPT Study Group on Broadband ISDN).

(1) Beyond "Video Dial Tone"

NTIA's views on this issue have evolved over time. In June 1988, we recommended that telephone companies be permitted to offer video distribution facilities on a common carrier basis.[826] Under this "video common carriage" or "video dial tone" concept, a LEC could construct, operate, and maintain a transport facility within its local service area, the channel capacity of which would be leased to unaffiliated programmers on a common carrier basis. Lease rates for channel capacity would be regulated to ensure that they were reasonable and nondiscriminatory. NTIA also recommended, however, that the prohibition on LECs' selecting, owning, or controlling the programming provided over their facilities be continued.[827]

In July 1990, NTIA, on behalf of the Administration, testified in support of legislation (S.2800) that would have removed the prevailing ban on telephone company provision of video programming, subject to certain limitations and safeguards. We there stated that allowing telephone companies to provide cable service would raise the prospect of another effective provider of multichannel video programming to television viewers, thus

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[825] This issue has recently been debated in the United Kingdom as well. The British government has concluded that while British Telecom should be barred from the provision of video programming in the short term, the potential benefits to consumers of the integrated provision of entertainment and telephone service, and the prospect of genuine competition in the provision of such services warrant allowing BT into this market over the longer term. *See Duopoly Review, supra* note 713, at 46. For further discussion, see Appendix E.

[826] To accomplish this, NTIA supported removal or modification of existing policies that could impede telephone companies from providing such distribution facilities. *See Video Study, supra* note 379, at 39-43. NTIA identified two impediments: (1) the apparent requirement in the Cable Act and FCC decisions that telephone companies may only provide video distribution facilities to franchised cable operators, *see id.* at 40-43, and (2) FCC rules that severely limit the range of "ancillary" services that telephone companies may provide to programmers that lease capacity from the telephone company. *See id.* at 43.

In March 1990, NTIA argued that, on the basis of the statute and legislative history, it was reasonable to conclude that the Cable Act "either compels common carriers to lease facilities only to franchised programmers, nor requires all providers of video programming to obtain franchises." Comments of NTIA in MM Docket 89-600, at 15 (filed Mar. 1, 1990) (NTIA Cable Comments). We also contended that the Cable Act does not appear to require common carriers that lease distribution facilities for the provision of cable programming to obtain franchises in certain circumstances. *See id.* at 18-22. We recommended that the FCC so construe the Cable Act or request clarification from Congress. *See id.* at 22.

[827] *See Video Study, supra* note 379, at 8.

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offering direct competition to incumbent cable system operators.[828] We also pointed out that telephone company entry into cable could generate important benefits beyond expanding competition in the provision of video to the home. The opportunity to provide programming should increase telephone companies' incentives to construct integrated broadband network facilities to carry that programming to the home. In turn, those facilities could make available a vast array of voice, data, and video services to subscribers.[829] Indeed, there are clear public interest benefits in permitting LECs to provide or package video programming themselves over their own facilities, so long as they also offer video transmission capacity on a common carrier basis to unaffiliated program providers and are subjected to FCC safeguards designed to prevent discrimination against competitors and cost shifting that could harm ratepayers.

In the *Video Study,* NTIA described its policy reasons for establishing a "common carriage" requirement for LECs that participate in the cable business.[830] We continue to endorse this "common carriage" principle. However, the *Video Study* also discussed several policy concerns that informed its position that LECs should not select, own, or control the programming provided over their facilities. Among these were what the *Video Study* described as "traditional concerns"—that LECs would (1) impede the development of non-video broadband services, (2) cross-subsidize unregulated programming activities, to the detriment of competitors and consumers, (3) abuse pole attachment access and rates, and (4) improperly exercise control of program content and diversity.[831] In addition, the *Video Study* raised concerns about diversification of LEC operations, cable concentration and vertical integration, but did not identify them as being decisive in justifying its policy position regarding LEC provision of programming.[832]

In reexamining the *Video Study's* analysis, we believe that the concerns it expressed about LEC participation in programming either may be overstated or can be addressed through FCC safeguards. As a result, these concerns could be outweighed by the potential benefits that LEC participation in programming can bring.

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[828] *See Communications Competitiveness and Infrastructure Modernization Act of 1990: Hearings on S.2800 Before the Subcomm. on Communications of the Senate Comm. on Commerce, Science and Transportation,* 101st Cong. 2d Sess. 28 (1990) (*Cable/Telco Testimony*) (statement of Thomas J. Sugrue, Deputy Administrator of NTIA).

[829] *See id.* at 29.

[830] *See Video Study, supra* note 379, at 37-40.

[831] *See id.* at 50-58.

[832] *See id.* at 58-60.

Well-developed safeguards can address two of the "traditional" concerns of the *Video Study,* regarding cross-subsidization and also discrimination, as evidenced by the history of pole attachment access and rates. The FCC's accounting and cost allocation rules can adequately control the danger of cross-subsidization of a LEC's programming activities by its regulated operations. As we stated in a recent filing with the FCC concerning so-called "enhanced services," those rules are extensive and effective in controlling cross subsidy of the type discussed in the *Video Study.*[833] LECs should be permitted to offer programming in their service areas only if they are subject to such rules.[834]

Concerns about discrimination, as in the case of pole attachments, can be addressed in several ways regarding pole attachments specifically. As the *Video Study* notes, there is an elaborate statutory and regulatory mechanism in place to address pole attachment disputes.[835] Moreover, this issue should be less serious than in the past, since nearly 90 percent of U.S. homes have access to cable television today.[836]

More generally, we believe that safeguards should be in place to prevent LECs from discriminating against competing program providers that use their common carrier facilities. The antidiscrimination and pro-efficiency requirements of the FCC's ONA rules for BOC provision of enhanced services would be effective ways to satisfy these goals. As we have noted, by guaranteeing nondiscriminatory access to LEC transmission facilities, ONA could foster competition in the provision of the services, such as video programming, built upon these facilities.[837] Indeed, for these regulatory purposes, video services are basically another type of "enhanced service" for which the FCC's ONA regime should be generally applicable. Nevertheless, we recommend that the FCC examine in a rulemaking proceeding whether video services require any modifications or additions to the ONA rules in order to protect against discrimination or promote efficiency in this particular marketplace. Such a rulemaking will be required in any event to remove the existing FCC-imposed ban on LEC provision of video programming.

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[833] *See* Comments of NTIA in CC Docket No. 90-623, at 8-13 (filed Mar. 8, 1991). While supporting the current rules, we also supported FCC initiatives to improve them in several specific respects. *See id* at 12-13.

[834] The increased use of incentive regulation of LECs by the FCC and the states also decreases incentives to cross-subsidize.

[835] *Video Study, supra* note 379, at 52-53.

[836] *See Competition, Rate Deregulation and the Commission's Policies Relating to the Provision of Cable Television Service,* 5 FCC Rcd 4962, 4966 (1990) (*FCC Cable Report*).

[837] *See Cable/Telco Testimony, supra* note 828, at 31-32.

LECs should not be barred from providing video programming because of a concern that, in doing so, they will impede development of other, non-video, services that cable companies could provide. To some degree, this concern, which the FCC first expressed in 1970,[838] has been reduced by changed circumstances. Such services, as provided by cable companies, have not developed to any great extent even with the existing restriction in place.[839] Moreover, to the extent that this concern goes to the potential for LEC discrimination against competitors, appropriate safeguards by the FCC, rather than a blanket prohibition, are appropriate.

LEC common carriage of unaffiliated programming, combined with LEC ability to provide programming, will promote, not hinder, diversity. A prohibition on LEC participation in programming over its own facilities would limit a voice—that of the owner of those facilities—from being heard. This, of course, is not the way in which existing cable firms, which are often the only multichannel video providers in their service areas, operate. In order to maximize diversity, the LEC should be able to be one of the many voices carried over its facilities. The nondiscriminatory common carrier model for LEC participation in the home video market[840] will promote diversity by permitting both the LEC and unaffiliated video providers to deliver programming over LEC transmission facilities. As we discuss below, lifting the current cable-telco cross-ownership restriction may result in increased LEC incentives to build competing multichannel video delivery systems. Unless such competition occurs, there may not be as much diversity in the supply of multichannel video services in many communities as would otherwise be possible.[841]

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[838] *See Section 214 Certificates*, 21 FCC 2d 307, 324-325 (1970).

[839] *See, e.g., Local Exchange Competition, supra* note 6, at 38-39, 45, 47-48. As discussed below, NTIA supports increasing competition in the provision of local exchange services generated by cable firms and other providers.

[840] The common carriage requirement will limit an LEC's control over the content carried over its facilities. Furthermore, because it is well established that a firm can be a common carrier for some purposes but not for others, *see FCC v. Midwest Video Corp.*, 440 U.S. 689, 701 n.9 (1979); *National Ass'n of Reg. Util. Comm'rs v. FCC*, 533 F.2d 601, 608 (D.C. Cir. 1976), a LEC could serve both as a regulated common carrier provider of video distribution facilities to unaffiliated programmers and as an unregulated programmer, exercising its First Amendment right to speak, itself.

[841] There is a possibility that LECs will attempt to enter the video services market simply by acquiring existing local cable television systems. We are concerned about the competitive consequences of such acquisitions. Entry *de novo* would promote infrastructure development since LECs would have greater incentives to deploy within their switched networks the broadband capabilities necessary to deliver video in competition with the local cable system. As noted *infra*, once deployed, such switched broadband networks would have the ability to deliver a wide array of new services. We note in this regard that we also strongly endorse permitting cable companies to use their facilities to provide telecommunications services that have traditionally been treated as "local exchange" services and frequently reserved to the LECs on a monopoly basis. *See infra* note 966.

Thus, the likely benefits of LEC entry into the video programming business outweigh the potential costs of LEC provision of video programming, which either are overstated or can be effectively ameliorated by adapting existing regulatory safeguards to suit the video programming marketplace. Such entry would be one important means for expanding competition in the provision of video programming to the home. LEC provision of video programming would offer direct competition to incumbent cable systems.[842] Moreover, requiring LECs to make channel capacity available on a common carrier basis would multiply opportunities for entry by independent program providers, thereby stimulating competition still further.

(2) Infrastructure Development

Repealing the cable-telephone company crossownership restriction could also promote development of the U.S. telecommunications infrastructure.[843] The opportunity to provide programming should increase LECs' incentives to construct integrated broadband network facilities to carry that programming to the home.[844] This, in turn, could lead to the introduction of a wide range of innovative voice, data, and video services for subscribers.[845]

As noted above, controversy remains over numerous technical issues associated with the development and deployment of integrated broadband systems. In the Notice, we focused on the relationship between the possibility of LEC provision of video programming and its effects on infrastructure development. Specifically, we solicited comments on two possible reasons why LECs might be reluctant to construct such networks if they cannot offer programming.[846] We discuss comment on those issues below.

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[842] *See Cable/Telco Testimony, supra* note 828, at 28.

[843] *See id.* at 29.

[844] Such facilities could, of course, use a variety of technologies to obtain the bandwidth necessary to carry video programming. Although, as we have discussed, fiber optic cable can provide such bandwidth, it is increasingly feasible to use digital compression techniques to transmit video signals over traditional copper facilities. Moreover, there are a number of trials underway that use hybrid fiber/copper and fiber/coaxial cable facilities to deliver broadband signals to subscribers. The precise mix of transmission technologies that will eventually be used in future broadband networks depends on numerous cost-performance tradeoffs that may differ for different users or regions.

[845] *See Cable/Telco Testimony, supra* note 828, at 29.

[846] We note that several LECs expressed a willingness, under certain circumstances, to construct video distribution facilities, even if they are not allowed to provide programming. *See* Comments of United Telecommunications, Inc. at 14; Comments of Southwestern Bell Corp. at 49; Comments of NYNEX Corp. at 101.

(a) "Risk Minimization"

First, we noted LECs' contention that allowing them to provide programming would reduce their risks in building broadband networks because they then would be assured of having at least one source of video programming for their networks.[847] We also asked whether LECs need the opportunity to provide programming so that they will have sufficient "negotiating flexibility" to attract to their networks established programming services that are either controlled by cable operators or that depend on cable systems for the bulk of their revenues.[848]

(i) Comments

Several LECs contend that the risks of deploying transmission facilities without an assured supply are programming are too high to justify making the necessary investment. USTA asserts that cable companies have no incentive to use LEC-constructed distribution facilities because they have market power in their franchise areas, and "a high level of integration promotes control over both their own local networks and proprietary programming." USTA then states that "[n]o exchange carrier would undertake the risk of building a broadband switched network relying only on unreliable revenue contingencies."[849]

Southwestern Bell notes that, if the LECs were to serve only as video common carriers, they would be dependent upon program providers, who "would not even exist at the time of deployment of [the firm's] broadband network."[850] On the other hand, "if the LEC were to wait to deploy the network until the program providers, services, and subscribers are in place, the program providers may be committed already to competitive networks."[851] In Southwestern Bell's view, to build a broadband network under these circumstances "would carry great economic risk."[852]

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[847] *See* Notice, 55 Fed. Reg. at 811, para. 96.

[848] *See id.*

[849] Comments of USTA at 29.

[850] Comments of Southwestern Bell Corp. at 49.

[851] *Id.*

[852] *Id.* The firm suggests that this risk would be mitigated if multiple video providers were permitted into the market.

Finally, Bell Atlantic states that because cable systems do not face competition, they would have no incentives to use LEC-constructed distribution systems, even if the latter were superior to the cable systems.[853] Thus, if LECs cannot provide programming themselves, their only other source of revenues would be independent firms trying to challenge "an existing cable company monopoly."[854] The chance that such firms will do so is, in Bell Atlantic's eyes, "an insufficient basis upon which local exchange carriers can justify deploying billions of dollars of optical fiber."[855]

INTV argues that this risk analysis is "unconvincing and counter intuitive."[856] In INTV's view, if the LECs "cannot conceive of switched video services that will be demanded by the American public," government should not eliminate the cable-telco crossownership rule in order to "stimulate a service when the proponents of the very service are unsure of its marketability."[857] NCTA concedes the need for there to be at least one source of programming supply for an LEC's broadband network, but questions "why LEC participation is necessary to produce this programming."[858]

(ii) Discussion

In evaluating comments on this aspect of LEC entry into video programming, we note that in the video marketplace, integration of program production or ownership and program distribution is quite common. Thus, most of the largest cable multiple system operators (MSOs) hold ownership interests in some of the programming services that they deliver to subscribers. Indeed, by 1990, MSOs had secured equity interests in four of the six national pay cable networks, and 24 of the 58 national basic cable networks, including 14 of the top 20.[859]

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[853] Comments of Bell Atlantic at 17.

[854] *Id.*

[855] *Id.*

[856] Reply Comments of INTV at 10.

[857] *Id.*

[858] Comments of NCTA at 35.

[859] *See* NTIA Cable Comments, *supra* note 826, at 54. *See also FCC Cable Report*, 5 FCC Rcd at 5007, 5109-5114.

The four national television broadcast networks—ABC, CBS, NBC, and Fox Broadcasting[860]—distribute programming to local broadcast affiliates throughout the nation, including stations (typically located in the largest metropolitan areas) that the networks own and operate.[861] Most other television stations also create at least a portion of the programming that they distribute within their communities of license. Moreover, motion picture studios frequently own chains of theaters in which their films are shown.[862] Indeed, in seeking to expand their overseas markets, a number of studios are investing in building theaters that can be used for the exhibition of feature films on the ground that such a distribution "infrastructure" is frequently lacking in foreign countries.[863] Finally, in a different but related market, two of the largest and most successful consumer electronics manufacturers—Sony and Matsushita—have recently acquired companies that produce the entertainment "software" (recorded music, films, and television programming) commonly used with these manufacturers' equipment, or "hardware."[864]

Undoubtedly, these firms made their decisions to integrate programming and distribution, software and hardware, for a variety of reasons. However, there appears to be at least one common denominator. All of the firms seem motivated by a desire to obtain a secure supply of one product (or to better control or coordinate the supply of one product) to increase the chances that another product or activity will succeed. Thus, as indicated in the Notice, cable systems have been increasing their investments in programming to guarantee a supply of quality programming that will enable their distribution businesses to compete effectively in the video marketplace.[865] Similarly, some have attributed Sony's acquisition of Columbia Pictures and CBS Records to Sony's desire to secure a reliable source of software for its hardware, thus enhancing that hardware's attractiveness to consumers.[866]

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[860] Fox Broadcasting is one of the largest and most influential members of INTV.

[861] The networks all produce some of this programming and acquire network distribution rights for the rest. The FCC recently amended its rules to permit the networks to acquire a broader set of rights in independently produced programming. *Evaluation of the Syndication and Financial Interest Rules,* 6 FCC Rcd 3094 (1991).

[862] *See* Stevenson, *In Hollywood, Big Just Gets Bigger,* N.Y. Times, Oct. 14, 1990, Sec. 3, at 12.

[863] *See, e.g.,* Groves, *Warners, UCI Move Multiplex Battle to German Front,* Variety, June 10, 1991, at 37; Groves, *TW announces co-ventures for European hardtops,* Variety, May 27, 1991, at 35.

[864] Sony has acquired both Columbia Pictures, a major Hollywood studio that produces both feature films and television programming, and CBS records. Matsushita has purchased MCA, another major producer of films and television programming.

[865] *See* Notice, 55 Fed. Reg. at 812, para. 100.

[866] *See id.* at 812, para. 99. In one recent example of this strategy, when Sony introduced its digital audio tape (DAT) player, it also had available for sale some 10 works from the CBS library in DAT format. *See* Hunt, *DAT Systems on Way to U.S. Market,* L.A. Times, June 5, 1990, Pt. F, at 1. Sony's ability to coordinate (continued...)

Thus, firms in the video and entertainment marketplace commonly invest in programming, or related "software," in order to, among other things, reduce the risks associated with distributing or making it available to consumers. It is therefore not surprising that telephone companies would likewise seek the opportunity to invest in programming as a way to minimize their risks in constructing and providing video distribution facilities.

NTIA also does not underestimate the potential difficulties that LECs may have in obtaining programming for their distribution facilities, if they are not allowed to develop or acquire it themselves. In this regard, we note that there have been persistent complaints about the availability of cable programming networks, whether commonly owned with cable systems or not, to alternative video distribution media, such as MMDS, SMATV systems, or home satellite dishes. In some cases, the cable networks have declined to deal with alternative distribution media, preferring instead to deal exclusively with cable systems.[867] In others, there are wide disparities in the rates paid for programming by cable systems and alternative media.[868]

The cable industry has vigorously defended these practices.[869] In particular, it has pointed out that integration into programming and exclusive dealing arrangements are common among video service providers.[870] The industry has also argued persistently, and in our view persuasively, that such arrangements generally enhance efficiency and

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866 (...continued from preceeding page)
DAT Systems on Way to U.S. Market, L.A. Times, June 5, 1990, Pt. F, at 1. Sony's ability to coordinate closely the release of DAT hardware and software may help stimulate sales for both, as well as overcome possible reluctance on the part of other record companies to support the DAT format, or on the part of consumers to purchase DAT players without available software.

[867] *See FCC Cable Report*, 5 FCC Rcd at 5021-5022, 5025. In some cases, cable networks will make their programming available to alternative distribution media, but subject to restrictions that prevent the latter from marketing that programming in areas served by a cable system that also carries the programming. *See id.* at 5023-5024.

[868] *See id.* at 5022, 5024-5025.

[869] *See, e.g.*, Comments of Turner Broadcasting System in MM Docket No. 89-600, at 15-18 (filed Mar. 1, 1990). The cable industry also asserts that the extent of its use of exclusive dealing arrangements has been overstated by industry critics, and that most cable programming is available to competing distribution systems. *See, e.g.*, Letter from Thomas Burchill, President, Lifetime Television, *et al.*, to Senator George J. Mitchell (June 18, 1991); Klein, *The Consequences of Vertical Integration in the Cable Industry* 52-55 (June 1988) (submitted as an appendix to Comments of NCTA in MM Docket No. 89-600 (filed Mar. 1, 1990)). As noted in the text, however, the record compiled in this inquiry and in FCC proceedings indicates that the cable industry does engage in various forms of exclusive dealing for some of their programming and that even when programming is available to competitors, the rates charged to different distribution systems offer vary widely. While such price differentials may be justified by differences in the costs of dealing with various types of distribution systems and operators, it does not seem sensible to prohibit competitors of cable systems from investing in programming of their own.

[870] *See, e.g.*, Klein, *The Consequences of Vertical Integration in the Cable Industry* 50-51 (June 1988) (submitted as an appendix to Comments of the NCTA in MM Docket No. 89-600 (filed Mar. 1, 1990)).

promote investment in programming, to the ultimate benefit of consumers.[871] Given this strong case by cable companies and their programmers that vertical integration and reasonable forms of exclusivity should remain as options available to them for the development and distribution of programming, we see no basis for denying potential competitors, including LECs, the opportunity to invest in the development of their own programming to compete against incumbent cable systems.

(b) Using Programming Revenues To Support Network Development

In the Notice, NTIA also cited arguments that, if LECs could provide programming, they "could realize revenues in the programming market that would exceed those available from providing carriage of video programming to unaffiliated providers," which revenues could then be used to fund "investment in a broadband public network."[872] We posed a series of questions about the size and source of these revenues, and whether they would be of sufficient magnitude to justify construction of broadband facilities in the short term. Finally, we asked whether the argument assumed the existence of excess profits from programming, and inquired about their size and source, including the extent to which they might stem from economies of scope in the provision of video transmission and programming.[873]

The parties that address this issue generally repeat, without elaboration, the contention that provision of programming will generate revenues to support network development.[874] However, NCTA contends that in the competitive video services market that would be spawned by LEC entry on a common carrier basis (regardless of whether LECs have the right to offer programming), there will be no excess profits to contribute to network modernization, or any other activity.[875] NCTA says that such excess profits

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[871] *See id.* at 50-52. Because of these benefits of vertical integration and exclusive dealing arrangements within the cable industry, the Administration has opposed legislative proposals that would prohibit or substantially restrict the ability of certain cable operators and programming networks to utilize such arrangements. *See, e.g.*, Letter from Robert A. Mosbacher, Secretary of Commerce, and James F. Rill, Assistant Attorney General, to Senator John C. Danforth, at 2 (Mar. 13, 1991).

[872] Notice, 55 Fed. Reg. at 812, para. 102.

[873] *Id.* at 812, para. 104.

[874] *See, e.g.*, Comments of Cincinnati Bell Telephone Co. at 11; Comments of TIA at 9; Comments of Opt In America at 33.

[875] Comments of NCTA at 37-38.

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would arise only if a LEC were a more efficient provider of video programming than its rivals.[876]

Although the record did not shed much light on this issue, we agree that if, as we anticipate, LEC entry into video services under the revised video dial tone model that we are now endorsing stimulates an actively competitive video market, there will not be any long-term excess profits available to "subsidize" network development activities. We recognize, nevertheless, that LECs might conceivably realize efficiencies as program providers, based on the advantages of vertical integration of programming and distribution that we have recognized in today's cable industry—the rapid introduction of new, desirable services, better information on viewer preferences, and minimization of transaction costs.[877]

To the extent that such efficiencies[878] result in higher profits for the LEC, those monies would be available for network development. We note, however, that whatever profits that LECs realize from the provision of programming would be from unregulated operations, and thus, at least under current practices, could be used at their discretion. While LECs could use such revenues for network development, they could also be used for improvements in programming or even for dividends to their shareholders. The opportunity to earn these revenues could, however, provide the LECs with incentives to invest in the technological upgrades necessary to deliver video services over their networks.[879]

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[876] *Id.* at 38.

[877] *See* NTIA Cable Comments, *supra* note 826, at 55-57. One reason that effective safeguards are necessary for LEC participation in programming is to ensure that revenues result from such efficiencies, rather than from anticompetitive practices.

[878] LECs might also realize efficiencies in the delivery of certain ancillary, "video processing" services that add value to programming. *See infra* notes 888-889 and accompanying text.

[879] Nevertheless, our support for telephone company entry into video services is not based on an anticipation that there will be substantial "excess" profits from LEC programming activities available to "subsidize" network development. Rather, we anticipate that video service providers that deliver their signals over LEC networks—including both LEC-affiliates and independent providers—will, through the payment of common carrier charges for their use of those facilities, help "fund" the development and deployment of the required broadband capabilities in LEC networks. For the reasons discussed above, we believe that the prospects of this source of "funding" is enhanced if the LECs are not prohibited from being one of the video service providers using LEC distribution facilities.

(c) General Conclusions: LEC Provision of Programming and Infrastructure Development

Allowing LECs to own, control, and provide video programming over their own facilities, subject to effective safeguards, could promote infrastructure development by increasing their incentives to deploy integrated broadband systems and other advanced networks.[880] In general, government restrictions that have the effect of limiting the uses to which new technology can be put tend to be inefficient and anticompetitive, and retard investment in that new technology. In particular, we believe that the current cable/telco crossownership rules are having such an effect with respect to investment in broadband public network technology.

As discussed earlier in this report, broadband networks are capable of delivering many types of telecommunications services that would be valuable in enhancing the economic and social lives of all U.S. citizens.[881] Nevertheless, it appears that transmission of one-way entertainment video could be critical to the successful deployment of a broadband network, at least in the short term, because it is the one service requiring broadband capacity for which there already is well-established customer demand.[882] However, if the current regulatory and legislative prohibitions on LEC provision of video programming remain unchanged, especially given the uncertainties about current cable programmers' willingness to use LEC distribution facilities on a common carrier basis, LECs may base their network investment decisions on the assumption that their networks will *not* be used in an efficient and timely manner for the delivery of video entertainment programming. At a minimum, this scenario is a possibility that LECs will have to assess in a different light than if they had the option of entering the video programming and packaging markets themselves. Under these circumstances, the pace at which LECs would invest in the broadband network facilities needed to deliver such programming will likely

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[880] We note that giving LECs the freedom to provide video programming does not mean that they will deploy a certain type of network, or even that they will enter the video market at all. In any event, our concern here is not to specify the particular network design that might be deployed by any provider of video services. Rather, our objective is regulatory policies that permit rational investment in telecommunications facilities.

[881] *See supra* Chapter 3.

[882] While there are a multitude of potentially valuable applications that could make use of the telecommunications capabilities that could be provided through an integrated switched broadband network, the direction and pace at which markets will develop for these services, which are currently unavailable, are difficult to predict. Infrastructure investment predicated on expected revenues from these undeveloped, albeit potentially lucrative, services would likely proceed somewhat more slowly than if entertainment video were among the services available over the new networks.

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be slowed, as compared with a situation in which LECs were allowed to be program providers as well as common carriers.

On the other hand, allowing LECs to participate in the video services market, whether through acquisition and distribution of programming, through joint ventures with unaffiliated program providers, or through funding of program suppliers, could provide some assurance that LEC broadband distribution facilities will be used, in an active and timely fashion, for the distribution of video entertainment programming. In such an investment environment, the LECs will clearly have greater incentives to deploy such facilities. Moreover, once those facilities become established, they could well attract additional, unaffiliated program packagers,[883] thus giving LECs further incentives to expand and upgrade their broadband networks. Finally, the availability of broadband facilities will likely spawn new applications—video and non-video alike—as entrepreneurs and carriers devise new service offerings that will benefit the American public. In light of the potential for improved competition and infrastructure development, the current cable-telco crossownership restriction should be removed.

While NTIA is convinced that allowing LECs to provide video programming will serve the public interest in a variety of ways,[884] we emphasize again that for the full benefits of LEC entry to be realized, that entry must be accompanied by safeguards to protect against anticompetitive abuse.[885] One such safeguard—the key to a "video dial tone," or ONA approach to use of the LECs' underlying video distribution facilities—is, of course, the requirement that LECs provide video channel capacity on a common carrier basis. This requirement would apply both to the LECs' programming affiliate and to unaffiliated programmers, so that the LECs' distribution networks would be available on an "equal access" basis to all competitors. Second, accounting rules must be applied to ensure that costs properly attributable to an LEC's competitive video programming operations are not misallocated to its regulated activities.[886] In both of these areas, existing FCC rules could be modified or developed further in certain respects to permit effective regulatory supervision of LEC video services activities.

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[883] This assumes that LECs will be permitted by regulators to provide, and will be able to provide, transmission capacity at competitive rates.

[884] Some LECs have argued that the cable/telco crossownership restriction violates the First Amendment. *See, e.g.*, Comments of USTA in MM Docket No. 89-600, at 63 (filed Mar. 1, 1990). Although we believe that the cable/telco crossownership restriction does raise First Amendment questions, we have not addressed those issues in this report because we recommend, for policy reasons, that the restriction be eliminated. However, recognition of First Amendment rights for LECs in this area would not be inconsistent with continuation of their long-standing common carrier obligations in other respects. Moreover, because it is well established that a firm can be a common carrier for some purposes but not for others, *see supra* note 840, there is no legal or policy reason why a LEC could not be a common carrier with respect to its distribution facilities, and also one of the First Amendment speakers using those facilities to deliver video programming directly to customers. Indeed, imposing an obligation on the LEC to provide "equal access" to its underlying network transmission facilities would seem to be a legitimate, narrowly-tailored way to ensure that a LEC's exercise of its right to "speak" is consistent with its common carrier obligations and impedes neither competition nor the First Amendment rights of others. *See Associated Press v. United States*, 326 U.S. 1 (1945). Such a regulatory framework would seem to raise fewer First Amendment concerns than the present flat prohibition on LECs providing video programming.

[885] We note, however, that the growth of local exchange competition, which we discuss below, will reduce LECs' ability to engage in such conduct.

Recent legislative proposals to lift the cable-telco crossownership restriction would also require that LECs offer video programming only through a subsidiary separate from their local exchange service operations. While we do not believe that such a requirement is strictly necessary to prevent anticompetitive conduct, we also recognize that this is an area of considerable controversy and that such a restriction may be useful in providing assurances that LEC entry into the video services market will promote, not undermine, competition. Accordingly, providing that this safeguard is not implemented in so overly restrictive a fashion that it forecloses meaningful LEC participation in this market, we would not object to its imposition on LEC entry into the video services market.[887]

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[886] The potential for such cost misallocation (*i.e.*, cross-subsidization) would depend on the extent and nature of a LEC's involvement in the video programming business. For example, it appears that the risks of cross-subsidization posed by a LEC engaging in program production would be relatively small. Because such production would likely involve equipment, facilities, and personnel separate from those employed in the LEC's regulated telecommunications operations (or even its video distribution activities), there would be few, if any, joint or common costs that could be misallocated so as to advantage the LEC's video production business. Moreover, virtually the only transaction that the LEC's video distribution business would have with its regulated operations would be the purchase of regulated transmission services at tariffed rates, which should not permit many opportunities for cross-subsidization. This is not to minimize the need for regulatory safeguards to prevent cross-subsidization, but merely to suggest that the quality or quantity of the cross-subsidy problems are by no means unsolvable or uniquely problematic.

[887] Another important and controversial issue surrounding LEC provision of video programming concerns the extent to which television broadcast stations, particularly public broadcast station, will have access to LEC-constructed video distribution facilities. *See, e.g.*, America's Public Television Stations, ***Public Television Supports the Preservation and Enhancement of Public Telecommunications in Broadband Initiatives and Emerging Telecommunications Infrastructures*** (1991) (recommending that 30 percent of the capacity of any fiber optic broadband network be reserved for "public telecommunications services"); S.1200, 102d Cong., 1st Sess. (1991) (LEC providing video programming may not charge local broadcast stations "for making its signals available to subscribers"). We note that requiring LECs to afford competing video service providers (including broadcasters) "equal access" to the LECs' underlying transmission facilities should alleviate, to a significant extent, these concerns about broadcaster access to such facilities.

c. LEC Provision of Program Packaging or "Video Processing" Services

NTIA recognizes that there are other ways of allowing LECs to participate in the video services market, short of permitting them to own and control the programming itself. For example, the existing crossownership restriction could be modified so that LECs could "package" and distribute over their own facilities programming owned and controlled by unaffiliated entities. Additionally, as suggested in the Notice, LECs could be authorized to furnish certain "video processing" services that would involve the LECs in manipulating or repackaging programming provided by unaffiliated parties.[888]

These alternatives would be preferable either to retention of the of the existing crossownership ban or to implementation of a video dial tone approach with no LEC participation in programming at all. Program packaging would allow the LECs to compete directly with incumbent cable operators as providers of multichannel entertainment programming to subscribers in the LECs' communities. Video processing would allow the LECs to use the signal and information processing capabilities that could be incorporated into advanced digital networks to provide viewers with greater control over the programs they watch. Because video processing would entail providing consumers with services that neither conventional cable nor over-the-air broadcasting can currently offer, it could represent an opportunity for LECs to add significant value to, and create substantial consumer demand for, the video services delivered over their networks. Given these factors, it is quite possible that, even if the cable/telco crossownership restrictions were lifted entirely, many LECs might choose to enter the video services market principally as program packagers and providers of video processing services.

Nevertheless, we do not support limiting LEC entry into video services to program packaging or video processing. Rather, we believe that both competition in the video services market and development of the domestic telecommunications infrastructure will be enhanced if LECs are allowed at least the option of acquiring some ownership in video programming. Most importantly, limiting LECs to program packaging or video processing would, as with the case of video dial tone, raise questions about the terms and conditions under which LECs would be able to obtain the programming to be packaged or processed. Again, without the opportunity to secure a reliable source of programming through vertical integration—if that proved to be necessary—LECs may be unwilling to accept the risks of providing packaging, video processing, or the transmission facilities and computer equipment needed to make such services available.

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[888] *See* Notice, 55 Fed. Reg. at 812-813, paras. 105-107. For a description of the services or capabilities that might be deemed "video processing," see *id.* at 812-813, paras. 105-107. Several commenters expressed support for this proposal in the event that LECs continue to be precluded from providing programming. *See* Comments of TDS at 80-81; Comments of BellSouth Corp., App. F at 21-23; Comments of Northern Telecom at 86.

When we observe the substantial investments made by the cable industry in programming, we are concerned that leaving government restrictions in place on a potential new entrant's ability to make similar investments, if it decides that marketplace conditions so warrant, could dampen competition and make actual new entry less likely.[889] There are two possible explanations for the investments by the cable industry in video programming —first, that it represents efficient vertical integration and, second, that it is exclusionary conduct to impede the development of competition by making new entry more costly. We believe that the former is the case (and therefore have opposed the imposition of restrictions on such vertical integration) but, in either case, it is not good public policy to prohibit a potential new entrant from developing its own programming. Such prohibitions either deny the efficiencies of vertical integration to a new entrant, or disable it from responding effectively to the exclusionary tactics of an incumbent firm in a less than fully competitive market. In either case, the development of competition could be substantially impeded.

Additionally, allowing LECs to provide video processing would create the intractable problem of drawing a clear and sustainable line between permitted and prohibited video processing activities. Moreover, even if such line-drawing is possible, the line drawn may limit LECs' flexibility to evolve their video processing services over time to keep pace with changing technology and customer demand. For these reasons, although allowing LECs to provide program packaging or video processing would be an improvement over the *status quo,* the preferred policy would be to permit LECs the option of also investing in video programming.

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[889] Entry into the multichannel video services market is not a trivial undertaking—witness the struggle to date of the "wireless cable" and DBS industries to become major players in this market. We are optimistic that these industries will become important participants in this arena, but our point here is that, whether or not government should actively "promote" the development of competition in this market, it should certainly avoid erecting barriers that make the development of such competition more difficult.

B. Improving "Traditional" Regulation

While NTIA anticipates, and strongly supports, the introduction of competition into local telecommunications services markets, we recognize that such competition will not appear overnight. Accordingly, the need for regulation will continue, at least during the transition to competition. Indeed, to the extent that some local exchange services prove to possess natural monopoly characteristics, regulation of those services may have to continue for an indefinite period of time. The challenge for government policymakers is to craft a regulatory regime that strikes a balance between the desire to ensure reasonable rates, the need to promote efficient infrastructure investment, and the imperative to accord regulated firms sufficient pricing flexibility to respond to competition as it emerges.

1. Forms of Regulation

As stated in the Notice, the FCC and state regulatory commissions have traditionally sought to control monopoly service rates through "rate of return" regulation, which attempts to restrain rates by constraining the regulated firms' profits.[890] However, because of growing concerns about the inefficiencies and imperfections associated with rate of return regulation,[891] many regulatory agencies have abandoned it in favor of so-called "incentive" regulation, which seeks to create incentives that spur regulated firms to become more efficient than is commonly the case under rate of return regulation. One of the more popular types of alternative regulation is "price cap" regulation, which seeks to control prices, rather than profits, by limiting increases in regulated rates according to a formula that reflects the costs of providing regulated services and productivity gains.[892] Other forms of "incentive" regulation retain many of the features of rate of return regulation, but allow regulated firms to retain some portion of profits earned in

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[890] *See* Notice, 55 Fed. Reg. at 809, para. 79.

[891] For a general critique, see National Telecommunications and Information Administration, U.S. Dept. of Commerce, *NTIA Regulatory Alternatives Report*, NTIA Report No. 87-222, at 13-31 (July 1987) (*Regulatory Alternatives Report*).

[892] The FCC adopted price cap regulation for AT&T in 1989. *See Policy and Rules Concerning Rates for Dominant Carriers*, 4 FCC Rcd 2873 (1989), *recon.*, 6 FCC Rcd 665 (1991) (*AT&T Price Cap Order*). The FCC mandated price cap regulation for the BOCs and GTE in 1990, but made it optional for other LECs. *See Policy and Rules Concerning Rates for Dominant Carriers*, 5 FCC Rcd 6786 (1990) (*LEC Price Cap Order*). A similar form of price caps has been in effect in Great Britain since 1984, when the government abolished British Telecom's service monopoly and mandated that company's privatization. A form of price caps also is in effect in Australia. *See Australia Reform*, *supra* note 713, at 6-7.

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excess of their authorized rate of return in order to stimulate incentives in those firms to operate more efficiently.[893]

a. Effects on Incentives to Invest

NTIA strongly supports the continued replacement by the states of rate of return regulation with some form of incentive regulation.[894] Because incentive regulation generally induces firms to operate more efficiently, we believe that it will ensure that regulated services are provided at lower prices and at lower cost than is the case under rate of return regulation.

We also concur with those commenters that assert specifically that price cap regulation will be more conducive than rate of return regulation to efficient investment in infrastructure.[895] Under rate of return regulation, a firm's revenue requirement (which determines the rates the firm may charge) depends to a large extent on the size of the firm's rate base, *i.e.*, capital investment minus depreciation. As a result, regulators employing rate of return regulation typically scrutinize a regulated firm's investment decisions very closely. In some cases, the regulator may disallow a particular investment from the firm's rate base (meaning that the firm must recover the costs of that investment from shareholders, rather than ratepayers) or impose a monetary penalty for that investment. Thus, in 1984, the staff of the California Public Utilities Commission recommended that Pacific Bell be penalized $700 million for overbuilding and unjustified plant investments. After extensive negotiations, Pacific agreed to a $144 million penalty

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[893] More than 20 state regulatory commissions either have implemented or plan to implement this form of incentive regulation. *See* Bell Atlantic, *Regulatory Reform Update* (Oct. 19, 1990).

[894] NTIA supported the FCC's decision to adopt price cap regulation, although we had some concerns about the precise price cap scheme prescribed. *See, e.g.*, Comments of NTIA in CC Docket No. 87-313, at 7-10 (filed July 26, 1988); Reply Comments of NTIA in CC Docket No. 87-313, at 10-13 (filed Dec. 4, 1987). We also believe that other forms of incentive regulation provide some marginal improvement over rate of return although, because many of those approaches retain features of rate of return regulation, we think that they are inferior to price cap regulation. *See Regulatory Alternatives Report*, *supra* note 891, at 43-44, 46.

[895] We note that, if the so-called Averch-Johnson effect (*i.e.*, the theory that, under certain circumstances, a rate of return regulated firm could increase its profits by overinvesting in capital equipment) was prevalent under rate of return regulation, the switch to incentive regulation, particularly price cap regulation, could cause a reduction in investment (because a price cap regulated firm would not have the same incentive to overinvest). However, there is controversy over the extent to which the A-J effect actually occurs under rate of return regulation. *See Regulatory Alternatives Report*, *supra* note 891, at 24-26. More importantly, as our objective is to promote efficient investment, we look favorably upon a regulatory scheme that discourages overinvestment.

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spread out over four years. Investment disallowances have occurred in other jurisdictions as well.[896]

Further, although investment disallowances and penalties are relatively rare,[897] regulators influence regulated firm investment decisions in other ways. Regulated firms commonly discuss proposed investment plans informally with their respective commissions. If the commissions do not clear those plans in advance, the firms, rather than risk a subsequent disallowance, will either abandon their plans or modify them so as to secure commission approval. Because of this informal clearance process, the number of actual disallowances understates the extent to which regulators under rate of return regulation influence regulated firm investment practices. Moreover, the uncertainty engendered by this close scrutiny appears to dampen firms' incentives to make capital investments to upgrade their networks.[898]

In contrast, a price cap approach decouples regulated firms' investment decisions from the regulatory process because the prices that the regulators do scrutinize will change according to factors that are not directly influenced by the firms' investment choices.[899] Because firms regulated under price caps will be less vulnerable to regulatory disallowances of certain investments, they should be more willing than rate of return regulated firms to make new investments.[900] Additionally, because such regulation rewards those firms that operate more efficiently, it should also induce firms to invest in technologies that increase productivity and reduce the costs of providing service.[901]

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[896] *See, e.g., Mountain States Tel. & Tel. Co.*, Docket No. E-1051-84-100, Decision No. 54843 (Az. Pub. Util. Comm'n 1986); *Continental Tel. Co. of North Carolina*, 67 PUR4th 280 (N.C. Util. Comm'n 1985). In other cases, regulatory commissions may impose conditions on certain regulated firm investments. For example, under the California price cap plan, Pacific Bell must notify the California Public Utilities Commission whenever Pacific plans to install fiber optic cable beyond its feeder plant. *See Alternative Regulatory Frameworks for Local Exchange Carriers*, 107 PUR4th 1, 159-60 (Cal. Pub. Util. Comm'n 1989).

[897] *See* Comments of AHTUC at 34 (survey of FCC and some 17 state commissions indicates that, in the past six years, there have been three instances of capital investment disallowances, one by the FCC).

[898] *See, e.g., Alternative Regulatory Frameworks for Local Exchange Carriers*, 107 PUR4th 1, 85 (Cal. Pub. Util. Comm'n 1989); Comments of Ameritech at 60; Comments of NYNEX Corp. at 76-77.

[899] As noted above, some forms of "incentive" regulation retain many of the features of rate of return regulation. To the extent that those features include review of telephone company investment decisions for purposes of regulating rates, we are not convinced that the investment choices made under such regulation will be more than marginally different from those made under a rate of return regime.

[900] *See, e.g.*, Comments of NYNEX Corp. at 76-77; Comments of Ameritech at 60.

[901] *See, e.g.*, Comments of US West at 19. We acknowledge concerns that incentive regulated firms may attempt to cut costs by sacrificing service quality. *See, e.g.*, Comments of CCTU at 26.

(continued...)

b. Pricing Flexibility

Any incentive regulation plan must include provisions for some pricing flexibility on the part of regulated firms. As noted above, economic efficiency requires that prices reflect underlying costs. This economic principle will become a market necessity as competition increases. Thus, to the extent that some services are priced below cost now, regulated firms must have an opportunity to raise them over time.[902] Conversely, those firms must have flexibility to reduce rates that are now set above costs, particularly where they need to do so in order to respond to competition.

The FCC's price cap plan gives firms some freedom to raise regulated rates over time. Specifically, a price cap regulated firm may raise the price of any service as much as five percent annually (without triggering full tariff review), so long as the increase in its average service price does not exceed the applicable rate adjustment formula.[903] On the other hand, because other forms of "incentive" regulation schemes retain much of the

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[901] (...continued from preceeding page)

We are not convinced that this is a serious problem, however. For example, the very investments that permit a price cap regulated firm to reduce costs and improve productivity may have beneficial effects on service quality as well. *See AT&T Price Cap Order,* 4 FCC Rcd at 3153 (citing comments of PacTel).

Additionally, to the extent that price caps would increase firms' incentives to offer new services, it could also induce them to provide a level of quality that will attract customers to those services. *See, e.g.*, Reply Comments of NYNEX Corp. at 10. Even if service quality were a potential problem under price cap regulation, the better solution would be to regulate service quality, rather than to abandon a more efficient form of regulation. Indeed, most price cap schemes include a service quality monitoring component so that the relevant regulatory agency can require corrective actions, if necessary. In this vein, the FCC received the first semiannual service quality reports from its price cap regulated carriers on June 30, 1991. Although price caps and other forms of incentive regulation have not been in effect for long, we are not aware that any service quality problems have developed thus far that can reasonably be attributed to these regulatory reforms. *See supra* notes 495 to 513 and accompanying text.

[902] Two caveats are in order here. First, overall telecommunications costs have been falling in real terms in recent years as a result of greater efficiencies from improved technology and regulation. Assuming that this trend continues, it is possible that prices for some services can be brought into line with costs over time by maintaining price stability and allowing costs to fall to those price levels. Second, competition can be a powerful driver of greater efficiencies and cost reductions. As competition increases for local exchange services, prices that are now below the costs of the monopoly provider may actually prove fully cost-compensatory for firms operating in an actively competitive environment. In both these ways, actual price increases may not be necessary in a competitive market, even for services now priced below cost.

[903] *See LEC Price Cap Order,* 5 FCC Rcd at 6813-6814; *AT&T Price Cap Order,* 4 FCC Rcd at 3053. Under the FCC's price cap scheme, the regulated services of each carrier are assigned to several different service "baskets." *See LEC Price Cap Order,* 5 FCC Rcd at 6812; *AT&T Price Cap Order,* 4 FCC Rcd at 3051-3065. The carrier can raise the rate of any service up to five percent, so long as the increase in the average rate for the relevant basket does not exceed the price cap formula.

pricing inflexibility associated with rate of return regulation,[904] they may not give regulated firms much opportunity to raise rates to reflect costs.

Such alternative regulation schemes provide similarly limited freedom with respect to price decreases. The FCC's price cap plan permits some pricing flexibility (rates cuts up to five percent can be implemented without triggering full tariff review), but it appears that more is warranted. When AT&T or a LEC must cut prices in the face of competition, a five percent reduction may not be a sufficient response.

Although the FCC is rightly concerned about the potential for predatory pricing based on improper cross-subsidization,[905] that is only possible if the firm is able to offset its losses from the predatorily-priced service by raising the price of another service for which it faces less competition. The FCC could devise a mechanism for preventing predatory pricing short of denying regulated firms sufficient pricing flexibility to respond to competition. The FCC could, for example, structure its service "baskets" so that competitive and non-competitive services are not mingled together.[906] Alternatively, it could afford firms broad flexibility to reduce rates, yet treat any price decrease in excess of five percent as a five percent cut for the purposes of making an adjustment in the average rate for the relevant basket.

c. *Sharing Mechanisms*

Many forms of incentive regulation require a regulated firm to disgorge a certain share of profits earned in excess of an authorized rate of return to ratepayers or for some other purpose. Such "sharing" mechanisms are appropriate as a matter of policy. The principal advantage of incentive regulation is that it induces firms to become more efficient—that is, either to produce more output with the same amount of resources or to produce the same output with fewer resources. In either case, the result is an increase in total social welfare, although for some services, that welfare gain would typically be captured by the firm, rather than ratepayers.[907] In a competitive market, however, market forces would inevitably drive prices towards the reduced costs and compel the firm to give up at least a portion of its gains to consumers. Since one of the purposes of regulation is to replicate the results of a competitive market, we think it reasonable to include a sharing factor in an incentive regulation scheme.[908]

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[904] *See Regulatory Alternatives Report, supra* note 891, at 43; *Alternative Regulatory Frameworks for Local Exchange Carriers,* 107 PUR4th 1 (Cal. Pub. Util. Comm'n 1989).

[905] *See, e.g., LEC Price Cap Order,* 5 FCC Rcd 6814.

[906] Combining competitive and non-competitive offerings in the same service basket raises the potential that a firm could underprice the services subject to competition, and recoup potential losses by raising rates for the non-competitive services, all without violating the overall price cap. *See AT&T Price Cap Order,* 4 FCC Rcd at 3047. Because it was not practicable to place each service in its own "basket," the FCC adopted "price bands" to mitigate any potential for such cross-subsidization between non-competitive and competitive services. *See id.* at 3052.

Although most incentive regulation plans apportion excess profits among the firm and ratepayers, several state commissions are using sharing mechanisms to promote infrastructure development. These mechanisms can be either explicit or implicit. For example, the California Public Utility Commission adopted its price cap plan for Pacific Bell at the same time it authorized the firm to invest $404 million through 1992 to upgrade its network so that all of its switches would be capable of providing equal access to interexchange carriers.[909] The Michigan PSC has ruled that Michigan Bell may keep 75 percent of the excess earnings up to four percentage points above its authorized rate of return, if the firm commits roughly one-half of those earning to network improvements in areas approved by the PSC.[910] Finally, the Tennessee PSC has authorized two LECs to earn in excess of their authorized rates of return if they agree to spend those funds to upgrade their networks in accordance with a plan developed by the PSC.[911]

Other states have implicitly adopted sharing mechanisms by implementing so-called "social contract" regulatory schemes.[912] Under these plans, regulated firms are relieved of rate of return regulation, are afforded some pricing flexibility with respect to certain services, and agree to freeze other regulated rates for a designated period of time. Additionally, regulators either permit firms to make infrastructure investments without regulatory review and/or require them to make investments of a certain type (*e.g.*, replacing electromechanical switches with electronic switches, whether analog or digital) or in designated areas (*e.g.*, rural areas).[913] For example, in the rate "freeze" agreement reached by Southwestern Bell and the Missouri PSC, Southwestern Bell committed to replace its remaining electromechanical switches by 1992 and to upgrade all multiparty to single-party service by the end of 1997.[914] Under these approaches, ratepayers forego potential rate reductions or refunds in the near term (although they also avoid potential rate increases), in return for infrastructure improvements that not only could help maintain reasonable rates in the long term, but also could expand the range of available services or make existing or new services available to underserved areas.

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[907] The proportion of the welfare gain captured by the firm will depend on the elasticity of demand for the service or services involved. If demand is highly inelastic, as is the case for some regulated telecommunications services, the firm will be able to retain most of the welfare gains associated with its increased efficiency. However, unless demand is perfectly inelastic, consumers will receive at least a portion of the firm's efficiency gains in the form of lower prices.

[908] Moreover, periodic regulatory review of the results of a price cap regime, and adjustment of that regime, can produce benefits for consumers. *See LEC Price Cap Order*, 5 FCC Rcd at 6834-6835; *AT&T Price Cap Order*, 4 FCC Rcd at 3141-3143.

[909] *See Alternative Regulatory Frameworks for Local Exchange Carriers*, 107 PUR4th 1, 104 (Cal. Pub. Util. Comm'n 1989).

[910] *See Michigan Bell Tel. Co.*, 111 PUR4th 1, 21-23 (Mich. Pub. Serv. Comm'n 1990). If Michigan Bell fails to fulfill that commitment, it must refund 90 percent of the excess earnings to ratepayers. *See id.* at 22.

[911] *See* Telecommunications Reports, Aug. 6, 1990, at 12-14. The PSC's proposal has been opposed by the state cable television association and certain other groups, such as the American Association of Retired Persons, which argue that network upgrades are not needed and that any excess earnings by the LECs should be returned to ratepayers in the form of lower prices for existing services. *See* Communications Daily, Feb. 21, 1991, at 8.

[912] Such plans have been adopted in several states, including Vermont (*see Vermont Telecommunications Agreement*, 99 PUR4th 80 (Vt. Pub. Serv. Bd. 1988), *modifying Order of July 12, 1988*, Docket No. 5252), Kansas, and Missouri, *see* Comments of Southwestern Bell Corp. at 8-9.

NTIA generally supports the concept of using such explicit or implicit sharing mechanisms to promote infrastructure development.[915] These proposals represent laudable examples of innovative thinking at the state level on ways to reform traditional regulatory approaches to better achieve the efficiency and equity goals of telecommunications policy in the area of infrastructure development. Such an approach, by ensuring rate stability for certain key services—in particular, local, residential service—can be a politically viable means of permitting efficient investment to take place in a timely manner that might otherwise be stalled in a rate of return regime. Furthermore, this type of plan can be a practical means of using regulatory policies to achieve social policy objectives, such as the universal service goal of ensuring that all segments of a state's population have a fair opportunity to share in the benefits of advanced telecommunications.

Finally, the sharing mechanism could be employed to further universal service goals. Specifically, rather than rebate the ratepayer share of excess earnings to subscribers or devote it to infrastructure development, a regulator could direct some or all of those excess revenues to a fund that would be used to subsidize lifeline telephone rates, to support high cost areas, or to extend service to the disabled (*e.g.*, to fund TDD relay systems).[916] To the extent that such subsidies expand telephone subscribership, they would enhance the value of telephone service to all existing subscribers (because of the network externality) and, thus, at least partially compensate the latter for the rebates that they have foregone. At the same time, because the firm would not have be able to keep the excess earnings in any event, the fact that the monies have been shifted from one set of ratepayers to another should not dampen the firm's incentives to keep seeking efficiency gains in its operations.

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[913] *See Vermont Telecommunications Agreement,* 99 PUR4th 80, 85 (1988).

[914] *See* Telecommunications Reports, Oct. 10, 1989, at 15-16; Comments of Southwestern Bell Corp. at 9.

[915] We note that regulators could also employ sharing mechanisms to promote network reliability by requiring carriers to devote a portion of any excess earnings to investments that improve service reliability, or by allowing regulated firms to retain a larger portion of any additional earnings if they make such investments.

2. Regulatory Depreciation Practices

An infrastructure issue closely related to the form of regulation adopted for LECs is regulatory depreciation policy.[917] Competition and the accelerated pace of technological innovation are steadily forcing changes in long-standing depreciation practices within the telecommunications industry. For many years, regulators have established very long depreciation periods for most telecommunications equipment.[918] This policy benefits regulators and rate of return regulated firms alike. For regulators, long regulatory depreciation periods are conducive to low local telephone rates,[919] which both nominally promote universal service goals and avert complaints from ratepayers and politicians. For firms under rate of return regulation, low depreciation rates entail a correspondingly slow decline in the firms' rate bases, upon which they earn their profits.[920]

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[916] Currently, TDD relay systems are funded through surcharges on telephone service, state appropriated monies, or private donations.

[917] Depreciation is an accounting concept that describes the process by which firms recover, over time, the costs of a capital investment. For each year of that investment's "useful" life, a firm records as an expense a designated portion of the investment's original cost. The value of the investment on the firm's books of account is then decreased annually by the amount of that year's depreciation expense. Revenues equal to each year's expense are put into a "depreciation reserve" account, so that at the end of the investment's useful life, the firm will have an amount equivalent to the investment's original cost with which to fund new investment.

Depreciation is also an issue in federal and state tax policy. The following discussion focuses only on the implications of depreciation policies adopted by federal and state regulators for ratemaking purposes. We do not address whether the reforms that should be adopted for regulatory purposes should also be incorporated into federal and state tax codes.

[918] Useful lives (which were used to derive the prevailing depreciation rate) of 30 and 35 years were common until relatively recently. *See* Kahn and Shew, *Current Issues in Telecommunications Regulation: Pricing*, 4 Yale J. on Reg. 191, 243 (1987) (*Kahn and Shew*). Regulatorily-prescribed useful lives for much of the LECs' local distribution still typically exceed 20 years. *See* Comments of Centel Corp. at 13 (21.5 years); Comments of NYNEX Corp., App. E at 4 (28.8 years).

[919] *See* Notice, 55 Fed. Reg. at 810, para. 83; Reply Comments of PacTel at 2. As noted, firms treat depreciation as an annual expense, which, under rate of return regulation, can be recovered from regulated rates on a dollar-for-dollar basis. Accordingly, because prescribing lengthy useful lives can reduce annual depreciation expenses, it will also tend to keep regulated rates down.

Such regulatory depreciation practices must be changed. Adherence to historical depreciation practice in the face of rapid technological change has meant that the investment assets on regulated firms' books of account are consistently and, in many cases, substantially overvalued.[921] For monopoly firms under rate of return regulation such practices may hinder efficient investment in new technologies and services, while restraining rates below their efficient levels. When competition develops, the overvaluation of the assets of such firms presents the following dilemma: If rates are set at accounting costs (including the costs of the overvalued assets), the firms may not be able to compete with rivals using more modern, lower cost technologies.[922] If, however, rates are set to reflect economic costs (including the "true" value of the overvalued assets), firms under traditional rate of return regulation may not be able to generate sufficient revenues to recover the costs of their investments.[923] Because of the problems stemming from traditional depreciation practices, many commenters in this proceeding have emphasized the need for fundamental changes in those procedures.[924] We address these concerns below.

a. *Effects of Regulatory Depreciation Reform on Investment*

In general, NTIA agrees with the many commenters that assert that more rational regulatory depreciation policies will foster efficient telecommunications investment and, thus, promote infrastructure development.[925] As one commenter points out, accelerated depreciation will promote efficient investment in two ways. First, it will increase the LECs' cash flow, which they can then use to fund network investment.[926] Second, to the extent that depreciation policies reduce the risk that investment costs will not be fully recovered, those policies will both increase regulated firms' incentives to make such investments and reduce the cost of capital.[927]

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[920] *See Kahn and Shew, supra* note 918, at 243.

[921] *See id.* at 244. This overvaluation occurs because, in a period of rapid innovation, an asset's economic life (*i.e.*, its cost compared to that of the most efficient available alternatives) generally is shorter than its "useful" life as adopted for regulatory purposes (*i.e.*, the period (typically prescribed by the regulator) during which that asset can provide a desired level of service at acceptable cost). *See id.* When useful life is greater than economic life, the asset will be depreciated at too slow a rate, which, in turn, means that the asset's "book value" (*i.e.*, original cost minus accumulated depreciation) will be too high.

[922] *See id.*; Comments of NYNEX Corp. at 82.

[923] *See Kahn and Shew, supra* note 918, at 244.

[924] *See* Comments of PacTel at 41; Comments of US West Board of Advisors of Iowa at 1; Comments of Cincinnati Bell Telephone Co. at 4; Comments of TIA at 14-15; Comments of NGA at 2; Comments of ITN at 6-7.

[925] *See, e.g.*, Comments of BellSouth Corp., App. D at 13-22; Comments of Contel Corp. at 21; Comments of United Telecommunications, Inc. at 13; Comments of NGA at 2; Comments of TIA at 14-15.

Although we believe that depreciation reform will increase the incentives for, and occurrence of, efficient telecommunications investment, we caution that, while accelerated depreciation will increase the cash flow available for new network investment, this, by itself, does not guarantee either that investments will be made or that the investments made will be optimal or socially desirable.[928] Firms make investment decisions by considering a variety of factors in addition to the amount of cash on hand, including the need for the investment, its projected cost, and the anticipated return in relation to other investment opportunities. If these latter factors do not favor a particular investment, it will likely not be made, even if monies are on hand to fund it.[929]

Additionally, although adequate depreciation will mitigate the risks of non-recovery, there will always be some uncertainty about what constitutes an "adequate" depreciation rate, even if that figure is selected by the firm itself. Technological change and increased competition may quickly turn a depreciation plan that appeared reasonable when adopted into one that does not permit full recovery of the costs of the investment made. In other words, there is always some risk of non-recovery. While aligning an investment's "useful" life more closely with its economic life will diminish that risk, depreciation plans should be flexible enough to permit the firm to adjust to changing conditions in order to ensure recovery.

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[926] *See* Comments of NYNEX Corp., App. E at 1. *See also* Comments of California at 6; Reply Comments of the Staffs of the Indiana and Michigan PUCs at 7. We understand that LECs typically fund the vast majority of their construction budgets with monies derived from depreciation expenses. *See* Comments of NYNEX Corp., App. E at 1 (85-90 percent); Reply Comments of USTA, Attach. 1 at 24 n.53 (almost 95 percent of BOCs' construction programs in 1988 funded by depreciation).

[927] *See* Comments of NYNEX Corp., App. E at 1-2; *See also* Reply Comments of PacTel at 2-3.

[928] Comments of California at 6; Reply Comments of the Staffs of the Indiana and Michigan PUC at 7.

[929] In this regard, we note that, in 1988, U.S. LECs spent about 67 percent of their available cash flow on capital investment. For the BOCs, the comparable figure was 64 percent. *See MESA Study, supra* note 446, at Table H. One commenter suggests that these figures reflect the LECs' conclusion that there is no "need" for further network investments that would consume a larger share of their available cash flow. *See* Comments of AHTUC at 12-13. If that is true, increasing the LECs' cash flow via accelerated depreciation would have a negligible impact on their investment decisions. We note, however, that an equally plausible explanation for the cited figures is that the current regulatory climate is such that the LECs are not assured of receiving a sufficient return on additional investments to justify making them. Moreover, LECs have other reasonable and legitimate uses for their cash flow, including dividends to shareholders.

b. Regulatory Depreciation Reform: Specifics

Regulatory depreciation reform is needed in two essential respects. First, we concur with those who assert that existing depreciation rates must be "accelerated," in order to bring the "useful" life of an asset prescribed for regulatory purposes in line with its economic life.[930]

We understand that there has been significant progress made in accelerating depreciation rates in recent years. As one commenter notes, for example, the FCC has accelerated depreciation rates for large categories of LEC equipment.[931] State commissions have apparently taken similar actions.[932] We are encouraged by these developments, and recommend that the FCC and the states aggressively pursue further progress in the future.[933]

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[930] *See, e.g.*, Comments of Ameritech at 60-61; Comments of GTE Service Corp., App. A at 32-33; Comments of Rochester Telephone Co. at 28; Comments of Northern Telecom at 78-79. Shortening the useful life of an asset to reflect its true economic life will necessarily increase the rate at which it is depreciated.

We note that many commenters speak of "accelerated depreciation." *See, e.g.*, Comments of US West Board of Advisors of Iowa at 1; Comments of Rochester Telephone Corp. at 28; Comments of Minnesota Direct Dialog Council at 2. To the extent that this term refers to the increase in depreciation that results from aligning useful life with economic life, "accelerated depreciation" is an appropriate policy. On the other hand, if that term implies adopting regulatory or tax policies designed to produce depreciation rates greater that those based upon economic life, we believe that accelerated depreciation would be unwise because it could result in an inefficient increase in telecommunications investment. *See, e.g.*, Reply Comments of PacTel at 1. Similar observations—both pro and con—apply to the argument that the United States should accelerate its depreciation rates because they lag behind those prevailing in other nations. *See* Comments of Bell Atlantic at 3.

[931] *See Property Depreciation*, 83 FCC 2d 267 (1980), *recon.*, 87 FCC 2d 916 (1981); Fowler, Halprin, and Schlichting, *"Back to the Future": A Model for Telecommunications*, 38 Fed. Com. L. J. 145, 167-168 (1987) (*Back to the Future*); Comments of MCI Telecommunications Corp. at 10. In 1986, the Supreme Court ruled that the FCC could not preempt state commissions from adopting depreciation rates and schedules different from those prescribed by the FCC. *See Louisiana Pub. Serv. Comm'n v. FCC*, 476 U.S. 355 (1986), *rev'g* 92 FCC 2d 864 (1983).

[932] *See, e.g.*, Comments of New York PSC at 7; Reply Comments of NARUC at 7; Reply Comments of the Staffs of the Indiana and Michigan PUCs at 7-8. *See also* Comments of Bruce Egan, App. 1 at 11 (LECs' composite depreciation rates are now about 8 percent, implying an average useful life of 12 years; pre-divesture, the composite rates were about 5 percent, implying an average useful life of 20 years); Comments of Southwestern Bell Corp. at 34-35 (company's depreciation reserve increased from 18.8 percent to 29.5 percent between 1984 and 1988, indicating an increase in its underlying depreciation rates).

[933] We realize, nevertheless, that depreciation disputes between regulators and regulated firms will persist. While such disputes may reflect regulators' continued adherence to traditional depreciation practices, they may also stem from reasonable disagreements about how to define an asset's "economic" life. *See* Comments of NARUC at 7.

The second major facet of regulatory depreciation reform concerns recovering the LECs' investment in overvalued assets currently on their books of account. Several state regulatory commissions have attempted novel solutions to this problem. Connecticut, for example, has adopted an incentive regulation plan that allows Southern New England Telephone to apply some of its earnings in excess of the authorized rate of return to defray accelerated depreciation expenses.[934] Both Maryland and Pennsylvania have allowed LECs to use "windfall" profits resulting from tax changes and sharply lower costs of capital to write off their overvalued assets.[935] All three of these initiatives have the effect of apportioning the costs of retiring overvalued assets among shareholders (who do not realize additional dividends from the excess earnings) and ratepayers (who do not receive the rate rebates that commonly result from overearning by regulated firms). We support such initiatives and urge other regulators to consider them for their jurisdictions.

c. Depreciation Under Incentive Regulation

In the Notice, we suggested that regulatory depreciation policies should not affect LEC investment decisions in a jurisdiction that has adopted price caps or some other form of "incentive" regulation.[936] As one commenter points out, while this may be true under a "pure" price cap plan, it is not true with respect to the incentive regulation schemes that have been adopted to date.[937] According to the FCC's recently-implemented price cap plan for LECs, for example, the FCC will review the earnings of each price cap-regulated LEC within four years to ensure that the elements of initial price cap plan were well-specified.[938] To guarantee that the FCC will be able to calculate a firm's earnings (*i.e.*, rate of return) at the end of that period, it has decided to retain control over depreciation in the interim.[939] Given this decision, the decoupling of regulation and depreciation practices promised by price cap regulation does not occur.[940]

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[934] *See* Comments of SNET at 11.

[935] *See Kahn and Shew, supra* note 918, at 244 n.129.

[936] *See* Notice, 55 Fed. Reg. at 810, para. 84 n.103. *See also* Comments of California at 7; Reply Comments of PacTel at 2.

[937] *See* Comments of NYNEX Corp., App. E at 6-8.

[938] *See LEC Price Cap Order*, 5 FCC Rcd at 6834.

[939] *See* Comments of NYNEX Corp., App. E at 6.

[940] *See id.*, App. E at 7. We note, however, that since rate of return review under a price cap approach will likely occur less frequently than is the case under rate of return regulation, depreciation issues will be somewhat less prevalent under price caps.

Depreciation issues will be even more prominent in those jurisdictions that have instituted other forms of "incentive" regulation by modifying rate of return regulation to permit regulated firms to earn more than their authorized rate of return. These plans clearly contemplate continuing regulatory control over the firms' depreciation practices, again to enable the regulator to determine each firm's earnings. Further, because the earnings reviews often will be more frequent under these plans than under the FCC's price cap scheme, the influence that the state-prescribed depreciation rates will have on regulated firm investments will be correspondingly greater.

In jurisdictions that have adopted rate-of-return-based "incentive" regulation, the continuing importance of depreciation issues increases the need for the regulators involved to move swiftly towards more efficient and rational depreciation policies. With respect to the FCC's price cap plan, on the other hand, there is an alternative. To the extent that the FCC is concerned about detecting errors in specifying the elements of its plan (*e.g.*, the accuracy of the inflation factor and the appropriateness of the productivity offset),[941] it should attempt to do so directly (for example, by conducting an assessment of LEC productivity). By doing so, the FCC would not so directly implicate depreciation issues and thus dilute the efficiency characteristics of price cap regulation.

3. State/Federal Regulatory Relations

The regulatory reform issues that we have been discussing are but two examples of issues in which federal and state regulatory cooperation is necessary to promote efficient infrastructure investment. The state PUCs, and other branches of state government, have demonstrated their deep interest in infrastructure issues by providing NTIA with thorough and thoughtful comments on the issues raised in the Notice.[942] In this subsection, we focus on the relationships between state and federal regulatory agencies.

As indicated in the Notice, the Communications Act creates a bifurcated regulatory scheme for U.S. telecommunications, giving jurisdiction over interstate telecommunications services to the FCC and leaving intrastate services generally within the purview of the states.[943] We also indicated that this system of divided authority made it difficult to fashion coherent national telecommunications policies when, as has been the case in the recent past, federal and state authorities differ fundamentally over regulatory goals and programs.[944] One response, in the words of one commenter, would be for "the Federal jurisdiction to assert greater control over national telecommunications policy, and to assume regulatory responsibility for some services traditionally regulated at the state level."[945] However, most of the commenters that addressed this issue favor retention of the dual jurisdictional system created by the Communications Act.[946]

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[941] *See LEC Price Cap Order*, 5 FCC Rcd at 6834.

[942] *See* Comments of California; Comments of D.C. PSC; Comments of Florida PSC; Comments of Idaho PUC; Comments of New York PSC; Comments of Washington UTC; Comments of NARUC; Comments of the State of Hawaii; Comments of the State of Minnesota; Reply Comments of the State of Alaska; Comments of NGA; Comments of Oregon DGS; Comments of South Carolina DIRM; Comments of Town of Bloomsburg, PA; Comments of County of Los Angeles, Internal Services Division; Comments of Enertel; Comments of LMDDC.

The issue of the proper apportionment of regulatory authority between federal and state agencies does not admit of a clear-cut solution. In particular, it presents the question of the proper balance between the need for uniformity in U.S. telecommunications policy and the potential benefits of diversity in policymaking. The case for uniformity in policy —which would imply federal primacy in policymaking—flows primarily from the unified nature of the domestic telecommunications system. Because the same equipment and facilities are increasingly being used to provide a wide range of different services used in both interstate and intrastate communications, attempts to subdivide those facilities as "intrastate" and "interstate" for regulatory purposes are becoming more and more artificial, inefficient, and difficult to enforce. Moreover, different agencies with concurrent authority over the installation, depreciation, and replacement of such equipment and facilities will often have policy divergences that may impede modernization of the overall telecommunications system.[947] Finally, because telecommunications consumers typically are not interested in purchasing separate packages of intrastate and interstate services, non-uniform policies that permit some firms to provide one type of service but not the other, may undermine their ability to compete at all.

Although there are clear benefits to uniformity in policymaking, dispersing regulatory authority among a number of agencies also has its advantages. Telecommunications continually confronts regulators with issues for which there seldom is a single answer and about which reasonable people can disagree. Moreover, the pace of change within the telecommunications industry is such that a policy choice can become unwise in a relatively short period of time. Under these conditions, according states significant regulatory authority over telecommunications allows them to function as "laboratories" to experiment with innovative regulatory models and mechanisms. In this fashion, states can test economic assumptions, evaluate different methods of regulation, and assess the effects of particular policy choices, while ensuring that mistakes, if any, will not have national consequences.[948] The experiences gained from the various state experiments could then be used to forge consensus on national regulatory goals and policies.

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[943] *See* Notice, 55 Fed. Reg. at 814, para. 120.

[944] *See id.* at 814, para. 121.

[945] Comments of UTC at 10.

[946] *See, e.g.*, Comments of TDS at 56-57; Comments of ICA/CFA at 13; Comments of UCC at 8-9; Comments of Idaho PUC at 6.

[947] *See* Comments of Southwestern Bell Corp. at 35-36 (divergence of federal/state depreciation policies commonly results in the same piece of equipment being depreciated at two different rates, which impedes cost recovery and, thus, network modernization).

Much recent evidence suggests that the state "laboratories" are producing valuable and innovative policy products, in some cases laying the groundwork for FCC reform. The FCC's adoption of price cap regulation for AT&T and the LECs was prompted by experiments with alternative forms of regulation at the state level, including virtual deregulation (as in Nebraska), social contract regulation (as in Vermont), price cap regulation (as in New York and California), and other "incentive" forms of rate of return regulation (as in a number of states). Several state regulatory commissions are also at the forefront of the movement to promote the growth of local exchange competition by mandating interconnection between competing local exchange networks.[949]

NTIA nevertheless recognizes that state regulation has not always been a force for innovation and change. For example, in the early 1970s, state commissions vigorously resisted the FCC's efforts to allow end users to interconnect non-carrier-provided terminal equipment to the public switched network. Without federal preemption of state regulations prohibiting such interconnection,[950] CPE competition, and the substantial benefits that it has produced for consumers, would have been stunted, if not eliminated.

The introduction of competition into the interexchange market provides a second example of a temporary divergence between federal and state policies. After the FCC authorized competitive provisioning of interstate long distance services, most states were slow to permit new entrants to provide intrastate long distance services in competition with the incumbent provider, AT&T. Because, as noted above, many customers demand both interstate and intrastate calling capability, AT&T's rivals were at a competitive disadvantage until states—spurred by the AT&T divestiture—began generally to authorize intrastate long distance competition beginning in the mid-1980s.[951] Thus, federal preemption in this area proved unnecessary. However, had state restrictions on competition remained in effect, the federal policy promoting competition in interstate services would likely have foundered and, perhaps, been undercut altogether.

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[948] *See New State Ice Co. v. Liebmann,* 285 U.S. 262, 311 (1932) (Brandeis, J., dissenting) ("one of the happy incidents of the federal system [is] that a single courageous state may, if its citizens choose, serve as a laboratory; and try novel social and economic experiments without risk to the rest of the country").

[949] *See infra* notes 1012-1014 and accompanying text, note 1017.

[950] *See, e.g., Telerent Leasing Corp.*, 45 FCC 2nd 204 (1974), *aff'd sub nom. North Carolina Util. Comm'n v. FCC,* 537 F.2d 787 (4th Cir.), *cert. denied,* 429 U.S. 1027 (1976).

In short, although the "laboratory" approach facilitated by the existing bifurcated U.S. regulatory structure clearly has some benefits, it may not always function well from a national perspective. The challenge for policymakers is therefore to devise a scheme that permits uniformity in telecommunications policy, where it is necessary, yet preserves the flexibility to experiment with different regulatory approaches, where it is appropriate. This could be accomplished by specifying that the FCC has broad jurisdiction over the U.S. telecommunications industry, including the power to preempt state regulations that interfere with the achievement of national goals and policies, such as the introduction of competition[952] or the need for more rational network investment policies by carriers.[953]

Although the current dual regulatory scheme for U.S. telecommunications policy has, for the most part, worked reasonably well, we are concerned whether the FCC has sufficient authority under existing law to establish uniform national policies when that approach is necessary to best serve the public interest. Prior to 1986, courts routinely upheld FCC orders preempting state regulations that interfered with achievement of national goals and policies.[954] In 1986, however, the Supreme Court reversed an FCC order preempting state depreciation practices.[955] The Court found that it was possible to divide telephone company investment into interstate and intrastate components for the purpose of applying separate depreciation rules and that, in such circumstances, the dual jurisdiction scheme created in the Communications Act foreclosed federal preemption.

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[951] *See* National Telecommunications and Information Administration, U.S. Dept. of Commerce, *Telephone Competition and Deregulation: A Survey of the States*, NTIA Report 86-205, at 6-16 (Oct.1986). Nevertheless, this is an area in which the FCC did not need to preempt state regulations that were serving as barriers to the development of competition. While the states were much slower than the FCC to abandon regulations that effectively gave AT&T a monopoly on long-distance services, they all did eventually adopt a competitive approach. There are some instances in which competition in intrastate, intraLATA services—the long distance services that the BOCs are permitted to provide under the AT&T Consent Decree—is still restricted. However, for intrastate, interLATA services, competition is now the rule and even in the intraLATA area, state regulatory restrictions on competition are gradually eroding.

[952] For example, a competitive enhanced services marketplace has developed free from state rate or entry regulation. However, as a result of a recent court decision, states now have the authority to regulate at least some intrastate enhanced services. *See California v. FCC*, 905 F.2d 1217 (9th Cir. 1990). Although a number of state regulators apparently see no need to regulate such services, *see* Communications Daily, May 17, 1991, at 1-2, if regulation occurs in other jurisdictions and hinders the consumer and infrastructure benefits flowing from competitive provision of intrastate enhanced services, NTIA would recommend legislation to preserve the unregulated status of all enhanced services.

[953] We believe that the FCC should, as a matter of policy, exercise its preemptive authority cautiously and only after close consultation and coordination with the states.

Following the *Louisiana* decision, federal courts of appeals have both overturned and upheld specific FCC preemptive actions.[956] While the facts underlying these cases have varied, it also appears that the courts are applying the *Louisiana* holding in different ways.[957] These decisions have made it difficult to determine precisely the scope of the FCC's authority to overturn state regulations that are inconsistent with federal policies.[958] However, if future court rulings continue to circumscribe the FCC's ability to establish national telecommunications policies, congressional action to clarify and, if necessary, to expand in a measured and moderate fashion, the FCC's regulatory authority over U.S. telecommunications may be appropriate.

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[954] *See, e.g., Computer and Communications Indus. Ass'n v. FCC*, 693 F.2d 198 (D.C. Cir. 1982), *cert. denied*, 461 U.S. 938 (1984); *California v. FCC*, 567 F.2d 84 (D.C. Cir. 1977); *North Carolina Util. Comm'n v. FCC*, 552 F.2d 1036 (4th Cir.), *cert. denied*, 434 U.S. 874 (1977); *North Carolina Util. Comm'n v. FCC*, 537 F.2d 787 (4th Cir.), *cert. denied*, 429 U.S. 1027 (1976).

[955] *See Louisiana Pub. Serv. Comm'n v. FCC*, 476 U.S. 355 (1986).

[956] *See, e.g., California v. FCC*, 905 F.2d 1217 (9th Cir. 1990); *Public Util. Comm'n of Texas v. FCC*, 886 F.2d 1325 (D.C. Cir. 1989); *National Ass'n of Reg. Util. Comm'rs v. FCC*. 880 F.2d 422 (D.C. Cir. 1989); *California v. FCC*, 798 F.2d 1515 (D.C. Cir. 1986).

[957] In some cases, the court's ruling rejected the FCC's rationale for a specific preemptive decision, but, in remanding the case to the FCC for further proceedings, gave the agency another opportunity to justify its action. *See California v. FCC*, 905 F.2d 1217 (9th Cir. 1990); *National Ass'n of Reg. Util. Comm'rs v. FCC*, 880 F.2d 422 (D.C. Cir. 1989).

[958] Some of the issues involve the types of services included within the specific limitation on FCC preemptive authority contained in Section 2(b)(1) of the Act; the scope of the exception to Section 2(b)(1) recognized in *Louisiana* permitting preemption when it is "*not* possible to separate the interstate and the intrastate components of the asserted regulation"(*e.g.*, whether it establishes a "practical infeasibility" test or an apparently stricter "impossibility" test); and the nature and extent of the burden on the FCC to establish incompatibility between state and federal regulations when exercising its preemptive authority. *Compare Public Util. Comm'n of Texas v. FCC*, 886 F.2d 1325 (D.C. Cir. 1989) and *Illinois Bell Tel. Co. v. FCC*, 883 F.2d 104 (D.C. Cir. 1989) *with California v. FCC*, 905 F.2d 1217 (9th Cir. 1990) and *National Ass'n of Reg. Util. Comm'rs v. FCC*, 880 F.2d 422 (D.C. Cir. 1989).

C. Local Exchange Competition[959]

As in other areas of telecommunications, technological developments are increasing the potential for competitive entry into local exchange services. Deployment of digital technology may soon enable cellular radio systems to carry 10 times as many calls on the same frequencies as is the case today,[960] thus substantially alleviating at least the capacity constraints that have limited cellular radio's ability to compete with local exchange telephone service.[961] Future development of radio-based PCS may also increase opportunities for new entrants to offer service in competition with the now-dominant LECs.[962]

Moreover, the installation of fiber optic transmission facilities by cable television systems may enhance their ability to compete with LECs. For example, Time Warner has announced plans to upgrade its Queens, New York system with fiber optic trunk facilities that will enable the system to carry "high definition, widescreen TV, voice interactivity and linkages with computers, fax machines and [PCS]."[963] Additionally, Cox Enterprises, which owns the fifth largest cable MSO, recently purchased a substantial minority ownership interest in Teleport Communications, which gives Cox access to Teleport's state-of-the-art fiber optic networks in a number of major U.S. cities.[964] These and other developments are rapidly increasing the likelihood that cable firms will be able to offer local exchange services in competition with the LECs,[965] either by leasing distribution facilities to other local service providers or by providing service directly to customers.[966]

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[959] This section and other parts of this report addressing local exchange competition are being issued under the supervision of Thomas J. Sugrue, Deputy Assistant Secretary and Deputy Administrator of NTIA. Assistant Secretary Janice Obuchowski currently is recused from participating in the discussion of this particular issue.

[960] *See* Communications Daily, May 1, 1991, at 2.

[961] The FCC should ensure that sufficient radio spectrum is available to permit efficient growth of cellular and other radio-based telecommunications services. One way to accomplish this would be to create economic and regulatory incentives to encourage radio-based users to switch to wire media in congested areas, when consistent with other public policies. *See Spectrum Report, supra* note 13, at 155-157.

[962] A recent survey by A.D. Little found that 63 percent of those questioned would replace their existing telephones with PCS equipment. *See* Communications Daily, Mar. 28, 1991, at 5. This response apparently assumes that subscribers will have to pay no more that $10 above their current local service rate and no more than $100 for PCS equipment. *See id.*

[963] *See id.*, Mar. 8, 1991, at 3. *See also* Dawson, *New architectures for fiber may boost telcos' cable inroads*, Cablevision, July 18, 1988, at 41.

[964] *See* Communications Daily, June 20, 1991, at 7. Cox and Teleport's majority owner, Merrill Lynch, will give Teleport $80 million to fund further expansion. Cox also holds the cable franchise in Staten Island, New York, where Teleport has a high-tech office park and the world's largest commercial satellite earth station facility. *See* Reply Comments of Teleport Communications Group at 26.

These developments can only expand the local exchange competition that exists, to some degree, today.[967] According to one source, some 34 different firms are now offering or planning to provide alternative local telecommunications services in more than 38 cities in 26 states.[968] Given these circumstances, NTIA agrees with the many commenters that assert it is time to permit competition for local exchange services.[969] Accordingly, this section addresses local exchange competition in some detail, including its benefits, its feasibility, and its implementation. As discussed below, we believe that the public interest would be served by removing existing legal barriers to entry into the local exchange services market. Government regulators should facilitate competitive entry primarily by mandating interconnection among all firms that provide local exchange services to the public. Finally, to permit incumbent LECs to respond to the new entrants, and to ensure that entry is economically efficient, existing pricing policies will need to be reformed. This will entail deregulating, or allowing significant pricing flexibility for, services that face competition.

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[965] Similar developments are taking place abroad. For instance, in the United Kingdom, as part on its recent review of the duopoly market policy, the government concluded that cable television companies should be allowed to provide local telephone service in their own right. (Currently, cable operators may offer telephone service within their franchised area, but only acting as an agent for the two authorized telephone companies, BT or Mercury.) A number of cable firms, including several in which BOCs have significant ownership interests, have expressed an interest in offering local telephone service. *See Challengers for U.K. Telecoms Market Emerge*, Financial Times, Apr. 16, 1991, at 1.

Cable firms also are offering limited services in competition with telephone companies in other countries. In Japan, one cable company has registered as a regional "type I" telecommunications carrier (a carrier that owns and operates its own infrastructure) and is offering certain non-cable two-way services, including telemetry for water meters, telecontrol for reservoirs, and two-way transmission of medical data. *Koike, supra* note 776, at 135. In Canada, some cable companies offer competition to telephone companies in the provision of special services, such as security surveillance. *Canadian Telecommunications, supra* note 745, at 16.

[966] We understand that there is some controversy over whether cable television systems can effectively compete with LECs in providing point-to-point communications services. As noted above, *supra* note 814, some argue that cable systems will be able to provide switched broadband services more cheaply than LECs, while others disagree. Although we do not know which view is correct, we do believe that government regulations should not prevent the firms involved from contesting the issue in the marketplace. Accordingly, an important component of our call for local exchange competition is the removal of state regulations that prevent or inhibit cable television systems from providing telecommunications services in competition with LECs and alternative local exchange service providers.

[967] One commenter says that attempts to block competitive entry into the local exchange are "largely irrelevant" now because entry is already occurring. *See* Comments of Southwestern Bell Corp. at 59. *See also Local Exchange Competition, supra* note 6, at 34-43 (identifying various providers of competitive local exchange services); Comments of US West, App. B (listing, among other things, alternative local service providers in the US West region). Although entry is certainly occurring, the policies of many states continue to restrict competition in a variety of ways.

[968] *See* ALTS, *Competitive Local Telecommunications Status Report* (Mar. 1991) (*ALTS Report*). Competition for local exchange services exists, or is developing, in a number of other nations as well. Since Japan opened its marketplace to new competitors in 1985, 67 new "Type I" (facilities-based) carriers have been established, including seven regional (*i.e.*, local) telephone companies, three satellite carriers, 16 firms offering cellular radio service, and 36 firms offering radio paging service. In addition, there are over 900 "Type II" carriers that offer either general and specialized services using facilities leased from Type I carriers. Ministry of Posts and Telecommunications, *An Outline of the Telecommunications Business*, 2 (1991). As a result of the U.K. government's recent decision to abolish its duopoly policy, numerous entities have expressed an interest in applying for licenses to provide domestic telephone service in Great Britain, both local and long-distance, including British Rail, British Waterways, British Gas, the Post Office, several electricity boards and water companies, overseas telecommunications service providers, (continued...)

Although we are convinced that local exchange competition will produce substantial benefits for telecommunications users and will promote efficient investments by local service providers, we nonetheless recognize that competition in the local exchange will erode many of the elaborate cross-subsidies that have traditionally characterized much local exchange service pricing. For the most part, this is for the good, as the overall efficiency of the local exchange market will improve and the right economic signals will be given to both providers and users of telecommunications services. However, we also recognize that, to a certain extent, some of those subsidies played a part in promoting long-standing U.S. policy goals, including traditional forms of universal service. We will return to this issue in Chapter 7 and consider the alternative support mechanisms that can be developed to ensure that the efficiency gains associated with competition are not achieved at the expense of the equity goals underlying universal service.

1. Benefits of Local Exchange Competition

If the U.S. experience with the CPE and interexchange services markets is any guide, expanding competition in the local exchange services market should have beneficial effects on local prices, the variety and quality of available services, and infrastructure development. The limited competitive entry into local services markets that has occurred

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[968] (...continued from preceeding page)
commercial satellite providers, and various cable TV firms. *See British Telecom and Mercury Duopoly Ends*, Times, Mar. 6, 1991, at 25; *Challengers for U.K. Telecoms Market Emerge*, Financial Times, Apr. 16, 1991, at 1; *Mercury Offers Freephone Service*, The Independent, Apr. 17, 1991, at 22.

[969] *See, e.g.*, Comments of Rochester Telephone Corp. at 24; Comments of NATA at 10-11; Comments of MessagePhone, Inc. at 6-9; Comments of California at 9-11; Reply Comments of AT&T at 23-24; Reply Comments of Litel Telecommunications Corp. at 5; Reply Comments of FMR Corp. at 14-15. *See also Back to the Future*, *supra* note 931, at 194.

to date provides ample support for that conclusion. As one commenter points out, for example, within two years after metropolitan area networks (MANs) began offering services in several LEC markets, the LECs reduced rates for certain of their federally-regulated, high-capacity circuits by 20-30 percent, on average.[970] New York Telephone also reduced its intrastate high capacity service rates in response to entry by MANs in New York City.[971] Competition also seems to have prompted LECs to substantially reduce their installation and repair times, thus improving the quality of service to customers.[972]

The emergence of alternative local exchange service apparently has also contributed substantially to the modernization of the local exchange infrastructure. By the end of 1989, alternative providers collectively had deployed nearly 34,000 miles of optical fiber in their various local networks.[973] The activity of these competing firms has prompted LECs to accelerate their installation of fiber optic cable within their networks.[974]

Expanding opportunities for competitive entry into the local exchange market should help extend the benefits of such entry to other telecommunications users, including residential telephone subscribers. The alternative local service providers have generally concentrated on serving interexchange carriers and larger business users.[975] At the same time, existing limits on local exchange service competition have hindered efforts by new entrants to serve smaller residential and business customers. For example, the growth of shared tenant services (STS),[976] which can provide alternative telephone service to business and residential customers in multitenant buildings, housing developments, and other campus environments, has been slowed, in part, by state regulatory decisions that STS constitutes unlawful resale of local service or that each STS customer must have a separate local access line, thus eliminating possible cost savings from shared local transmission facilities.[977] Removing such barriers to competitive entry would correspondingly expand opportunities to provide new and innovative services to more local exchange services customers. State regulation, or the threat of such regulation, has also in several instances deterred cable television systems from offering local exchange services in competition with LECs.[978]

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[970] *See* Comments of MFS at 15.

[971] *See id.* at 16.

[972] *See id.* at 28.

[973] *See id.* at 17-18. According to the U.K government, cable television companies are proposing to invest over £3 billion in new networks covering two-thirds of the country that will offer telephone service in competition with British Telecom. Department of Trade and Industry Press Release, *Telecommunications—Peter Lilley Sets Agenda for the 90's* 4 (Mar. 5, 1991) (*DTI Press Release*).

[974] *See* Comments of MFS at 18, 26-27; Kaplan, *Private Line and Special Access Competition in New York City* at 8, 17-18 (Jan. 1991). A commenter asserts, albeit without supporting documentation, that a $10 million investment by an alternative local exchange service provider can stimulate a $100 million investment by an LEC. *See* Comments of ALTS at 3.

One commenter suggests that competition can, by providing alternative paths for the transmission of communications, improve the reliability and survivability of local exchange services. *See* Comments of MFS at 22-29. Although this point is well taken, one must be cautious about the extent to which these potential benefits are realized at the present level of local exchange competition. If, for example, competing local exchange facilities occupy the same conduit, as is not uncommon, the fact that they are owned by separate entities does not reduce those facilities' vulnerability to cuts or similar failures. Moreover, some of the benefits of diverse routing promised by competition could remain largely unrealized unless a provider is prepared to route its traffic over competitors' facilities in the event of a network failure, or unless users have the capability of routing their traffic over alternative facilities. Nevertheless, as local exchange competition grows,we believe that the reliability and survivability benefits of diverse routing will grow correspondingly.

[975] *See, e.g.*, Comments of MFS at 3.

2. Feasibility of Local Exchange Competition

Although local exchange competition can produce important benefits, we nonetheless recognize that the benefits are achievable only if competitive entry into local exchange services will both occur and persist.[979] The most commonly cited reason for believing that competitive entry into a market is not feasible is that the market is a "natural monopoly"[980]—that is, the demand and cost characteristics of the market are such that

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[976] In an STS operation, privately-owned switching equipment is used to connect CPE located in a building, real estate development, or campus. The switching equipment allows STS customers to communicate with each other without using the local exchange network. It also allows the STS operator to concentrate outgoing traffic before it enters the local exchange network, thus permitting a substantial reduction in the number of access lines needed to transmit that traffic. *See* Notice, 55 Fed. Reg. at 801 n.12, para. 7.

[977] *See Local Exchange Competition, supra* note 6, at 45.

[978] *See id.* at 45; Comments of Continental Cablevision at 41-42.

[979] Several economists have theorized that, if a market is "contestable" (*i.e.*, where entry and exit are both easy and essentially costless), a market served by a single firm will perform in a "competitive" fashion (with the attendant benefits) even if no other entry occurs. *See* W. Baumol, J. Panzar and R. Willig, *Contestable Markets and the Theory of Industry Structure* (1982). However, one of the proponents of this so-called "contestability theory" has suggested that provision of local exchange services may exhibit characteristics (*e.g.*, "sunk" costs, or costs that cannot be recovered upon exit from a market) that would render the local exchange market non-contestable. *See* Bailey and Baumol, *Deregulation and the Theory of Contestable Markets*, 1 Yale J. on Reg. 111, 136 (1984). For a brief critique of contestability theory, see Shepard, *Concepts of Competition and Efficient Policy in the Telecommunications Sector*, in *Telecommunications Regulation Today and Tomorrow* 79, 105-109 (E. Noam ed. 1983).

[980] *See, e.g.*, 2 *Kahn, supra* note 135, at 115, 146-152; *Back to the Future, supra* note 931, at 150-151; *Panzar, supra* note 809, at 4-5.

"it is less costly for a single firm to serve the market than it is for two or more firms."[981] Where natural monopoly conditions exist, competitive entry will fail, if the market is allowed to operate freely (*i.e.*, absent government intervention to sustain competitors artificially), resulting in a "wasteful" use of society's scarce resources by entrants.[982] In such cases, society would be best served by precluding entry and allowing the market to be served by the single efficient provider.

For a number of reasons, the natural monopoly model does not provide a convincing rationale for barring competitive entry into the local exchange services market.[983] First, it not clear whether that market, in fact, exhibits natural monopoly characteristics. While some observers believe that is the case,[984] others have reached the opposite conclusion.[985] Although this uncertainty exists, there is a substantial possibility that monopoly provision of local exchange services is a product of government fiat, rather than economic or technological factors.[986] Instead of accepting the natural monopoly paradigm, and maintaining regulations that perpetuate it, a positive step by government would be to remove legal barriers to entry.[987]

Second, natural monopoly analysis is necessarily static, as it considers whether the presence of a single provider is the most efficient outcome given the cost and demand

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[981] *Panzar, supra* note 809, at 4.

[982] *See id.* at 4. However, competitive entry may benefit society, even assuming natural monopoly conditions, if the incumbent firm is not operating efficiently. As noted *infra,* there are strong reasons to believe that a monopolist, "natural" or otherwise, would not operate efficiently.

[983] The "local exchange services market" is an agglomeration of discrete services, some of which are substitutable for others. For a general discussion of the types of these services, see *Local Exchange Competition, supra* note 6, at 3-6. For exposition purposes, we consider the local exchange a single market. However, a more detailed definition of the market would not affect our analysis.

[984] *See, e.g.*, 2 *Kahn, supra* note 135, at 127; *Panzar, supra* note 809, at 5; Greenwald and Sharkey, *The Economics of Deregulation of Local Exchange Telecommunications,* 1 J. Reg. Econ. 319, 320-323, 337 (1989).

[985] *See* J. Wenders, *The Economics of Telecommunications* 173, 235 (1987) (*Wenders*); P. Huber, *The Geodesic Network: 1987 Report on Competition in the Telephone Industry* 2.23, 2.25-2.26; Wenders, "Local Telephone Competition," at 2-7 (delivered at Bell Communications Research Deregulation Policy Conference, Apr. 1, 1987).

[986] *See, e.g.*, Report and Recommendations of the United States Concerning the Line of Business Restrictions Imposed on the Bell Operating Companies by the Modification of Final Judgment at 88, *United States v. Western Elec. Co., Inc.*, 673 F. Supp. 525 (D.D.C. 1987) ("state-imposed restrictions on intra-LATA competition operate to preserve the local BOC's bottleneck even as technology begins to make competition feasible".)

[987] *See Wenders, supra* note 985, at 173. As a general proposition, "[i]f a natural monopolist is producing and pricing as efficiently as possible, there is no need to bar competitive entry: it is economically unnecessary and will not take place anyhow." 2 *Kahn, supra* note 135, at 223.

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characteristics prevailing at a particular point in time. Accordingly, that analysis does not account for the dynamic changes affecting an industry, changes that can profoundly affect the soundness of any natural monopoly determination. In particular, technological change continually alters the cost characteristics of and conditions of entry into an industry.[988] In the process, "[i]t may create a natural monopoly or destroy one."[989]

Technological change in the telecommunications industry helped inject competition into the provision of long distance services, a market that had been commonly viewed to be a natural monopoly.[990] Given the continuing pace of technological development within the industry and the emergence of competition in local exchange service markets, there is no compelling reason to believe that such competition is not sustainable. As a result, government should be reluctant to continue restraints on entry based upon an unproven, static assumption that such entry will not persist.

Third, a monopoly, however "natural," is nonetheless a monopoly. As such, a "natural" monopolist has the same incentives as its unnatural brethren to maximize profits by raising price and restricting output, with the resulting welfare losses for consumers. As importantly, without the spur of competition, a monopolist lacks incentives to minimize its production costs, meaning that its output consumes too large a share of society's scarce resources. Available evidence suggests that these so-called "x-inefficiencies" associated with monopoly are substantial.[991]

To be sure, government can, through regulation, attempt to eliminate or mitigate these welfare losses associated with monopoly provision of local exchange services. However, regulation is an art, not a science, and a difficult art at that. Long experience as well as theory demonstrate that government regulators typically lack the information needed to distinguish efficient from inefficient behavior by regulated firms.[992] The political nature of the regulatory process frequently impedes regulators from developing and implementing economically efficient regulatory structures, even when they can be determined.[993] Accordingly, the presence of such regulation is a slender reed upon which to support continuation of government-imposed restrictions on entry into the local exchange market.[994]

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[988] *See Brock, supra* note 355, at 301.

[989] *Id.*

[990] *See id.* at 303.

[991] *See, e.g.*, Hollas and Herren, *An Estimate of Deadweight and X-Efficiency Losses in the Municipal Electric Industry*, 34 J. Econ. and Bus. 269 (1982) (study of 197 electric utilities found that welfare losses attributable to X-inefficiencies represented nearly 9 percent of total revenues). For a general discussion of X-inefficiencies, see Primeaux, *An Assessment of X-Efficiency Gained Through Competition*, 59 Rev. of Econ. and Statistics 105 (1977); Leibenstein, *Allocative Efficiency v. "x-Efficiency,"* 56 Am. Econ. Rev. 392 (1966).

[992] *See, e.g.*, Joskow and Schmalensee, *Incentive Regulation for Electric Utilities*, 4 Yale J. on Reg. at 12; *Alternative Regulatory Frameworks for Local Exchange Carriers*, 107 PUR4th 1, 85 (Cal. Pub. Util. Comm'n 1989).

Moreover, entry would have the very positive effect of reducing the inefficient cross-subsidization reflected in local exchange access pricing. We believe that the resulting savings would be substantial.[995] Although removing legal barriers to entry into the local exchange market entails some risks,[996] NTIA believes that policy should nonetheless be pursued. Given the uncertainties about the validity of the assumed natural monopoly characteristics of the local exchange market, the efficiency losses that would ensue if government should continue to protect the existing monopolies, and the clear efficiency gains that entry could cause in reforming current price structures, we are convinced that the benefits of open entry outweigh the potential costs.

We therefore recommend that the FCC and, more importantly, state regulators should remove remaining barriers to competitive entry into the local exchange services market, particularly exclusive franchise requirements and limits on resale of local exchange services.[997] In so recommending, we are not concluding that competition will necessarily be feasible in all local exchange service markets.[998] Indeed, it may be that single firm provision of certain facilities or services (such as basic residential telephone service) may continue for some time. However, removal of barriers to competitive entry at both the interstate and intrastate levels is important because of the unified nature of local exchange facilities and services. Entry limited only to interstate services ultimately may not be economically feasible (or enforceable). Because some states have already taken the lead in introducing local competition, we believe that the FCC should encourage them by adopting pro-entry federal policies that support the states' initiatives.

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[993] *See Wenders, supra* note 985, at 165.

[994] This is not to say that all forms of regulation are equally problematic. As we have discussed above, alternatives to rate of return regulation can provide regulated firms with greater incentives to behave efficiently.

[995] *See, e.g.*, Wenders and Egan, *The Implications of Economic Efficiency for U.S. Telecommunications Policy,* 10 Telecommunications Pol. 33 (1986).

[996] For example, if provision of local exchange service is a natural monopoly, open entry could conceivably produce welfare losses. For example, some economists contend that, under certain conditions, even an efficient natural monopolist may not be able to set welfare-maximizing prices without inducing entry. *See, e.g.*, S. Berg and J. Tschirhart, *Natural Monopoly Regulation* 236-279 (1988); W. Baumol, J. Panzar, and R. Willig, *Contestable Markets and the Theory of Industry Structure* 191-224 (1982). In such cases, permitting entry would be inefficient. Additionally, free entry could theoretically cause the incumbent firm to overinvest in order to deter such entry. *See* Stiglitz, *Potential Competition May Reduce Welfare*, 71 Am. Econ. Rev. 184 (1981). If additional entry is not sustainable (because of the natural monopoly characteristics of the market), the incumbent's investments may simply reduce its profits without increasing overall economic welfare. *See* Mankiw and Whinston, *Free Entry and Social Efficiency,* 17 Bell J. of Econ. 48 (1986).

[997] In a similar vein, in deciding to abolish the current duopoly market structure in Great Britain, the British government noted that the very existence of a monopoly is likely to foster inefficiencies, while "[i]ntroducing competition can create incentives for increased efficiency, greater choice, improved quality of service and greater innovation, which otherwise would not exist." *Duopoly Review, supra* note 713, at 28.

3. Implementing Local Exchange Competition

Although NTIA strongly favors expanding competition within local exchange services markets, we recognize that implementing this policy will require more than simply eliminating legal barriers to competitive entry. For example, as discussed below, other barriers, such as lingering natural monopoly characteristics for some local exchange services or facilities, could, if not addressed, impede entry into any part of the local exchange market. Additionally, local exchange competition will compel changes in the existing, subsidy-laden rate structure for regulated local exchange services, which is sustainable only in a monopoly market environment. Finally, the proliferation of competing networks in local exchange (and other telecommunications service) markets will increase the need for coordination among the various providers to promote interconnection, ensure interoperability, and expedite introduction of new services. We discuss each of these issues in turn.

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[998] As a matter of sound policy, and recognizing the important local interests involved, decisions concerning removal of state-imposed entry barriers should be made by the respective state legislatures or, if authorized to do so, state regulatory commissions. We do not believe that federal preemption—whether by legislation or regulation—is appropriate at this time, although the FCC should closely monitor state actions with respect to existing entry barriers to determine whether preemption would be warranted at some future date.

In this regard, there are legal issues as to the extent of the FCC's authority to preempt state regulation in this area. *Compare Public Util. Comm'n of Texas v. FCC,* 886 F.2d 1325 (D.C. Cir. 1989) (FCC could preempt state commission order barring customer from interconnecting FCC-licensed microwave system with intrastate public telephone network through customer-owned PBX) *with California v. FCC,* 798 F.2d 1515 (D.C. Cir. 1986) (FCC could not preempt state regulation of intrastate common carrier uses of radio facilities on grounds that such regulation might impede or preclude FCC radio licensees from using those facilities to furnish interstate services). As noted above, depending on how case law develops in this area, the FCC may need new legal authority, through legislation, to preempt state action when necessary to protect the national interest in promoting local exchange service competition.

a. Facilitating Competitive Entry

As noted above, it is possible that certain local exchange services and facilities will retain substantial natural monopoly characteristics, at least for some period of time. Accordingly, it is unlikely that a new entrant will attempt to duplicate that portion of a LEC's network that contains those facilities or provides those services.[999] As a result, if the entrant is to have a meaningful opportunity to provide competing local exchange services, it will likely need access to the LECs' essential, or "bottleneck" facilities.

One way for regulators to afford alternative local service providers such access would be to mandate interconnection between the LECs and competing local exchange networks.[1000] Under this approach, for example, a competing local service provider could interconnect its facilities to a LEC central office in the same way and under the same terms as the LEC does and also to purchase LEC switching functions on an unbundled basis.[1001] In this way, the alternative provider can offer a competing local exchange service by piecing together its own facilities and features and facilities obtained from the LEC, much in the way that competing interexchange carriers first provided nationwide coverage by leasing circuits from AT&T to supplement the carriers' own facilities.

The availability of mandatory interconnection would promote competitive provisioning of those local exchange services and facilities that do not possess natural monopoly characteristics.[1002] Experience with the CPE and interexchange markets suggests that such competition will both stimulate continued improvements in the capabilities of those services and facilities and reduce their costs, to the ultimate benefit of telecommunications users. At the same time, giving access to those LEC facilities that may still have natural monopoly characteristics will spare new entrants from having to invest in duplicative facilities in order to enter the local exchange services market.[1003]

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[999] *See, e.g.*, Petition for Rulemaking of MFS, RM-7249, at 60 (MFS Petition) (citing *First Triennial Review*, 673 F. Supp. at 537-40).

[1000] In most cases, interconnection would occur at or near a switching office of the network provider from which interconnection is being requested. However, parties should have the freedom to accept other mutually acceptable interconnection arrangements.

[1001] *See* Comments of MFS at 7.

[1002] We recognize that mandatory interconnection requirements would be new regulatory burdens for LECs, although the greater pricing flexibility for LECs that we advocate would tend to lessen such burdens. Because interconnection is being used in this instance to expand competition in a market now dominated by the LECs, we believe the benefits of mandatory interconnection exceed the potential regulatory costs.

Using mandatory interconnection to give new entrants access to essential LEC facilities and, thus, to facilitate competition would be fully consistent with existing policies and practices. At the federal level, the competitive CPE market was spawned by FCC decisions declaring[1004] and enforcing[1005] a customer's right to interconnect non-carrier-provided terminal equipment to the LECs' networks. In 1974, the FCC required the Bell System to interconnect with the so-called specialized common carriers as a means of implementing the FCC's prior decision to authorize competitive provision of interstate private line services.[1006] Nine years later, the FCC again employed mandatory interconnection with LEC networks to promote competitive entry into interstate switched telephone services.[1007] Similar concerns underlay the FCC's interconnection decision orders with respect to cellular radio.[1008]

[1003] *See, e.g.*, MFS Petition, Petition for Rulemaking of MFS, RM-7249, at 66-68. To the extent that mandatory interconnection reduces the plant investment that firms must incur to enter the market, it should reduce the risks of such entry, provided that safeguards are established to prevent LECs from engaging in anticompetitive behavior. The reduced risk may, in turn, stimulate additional entry.

[1004] *See Carterfone*, 13 FCC 2d 420, *recon. denied*, 14 FCC 2d 571 (1968).

[1005] *See Interstate and Foreign Message Telephone Service*, 58 FCC 2d 736 (1976), *aff'd sub nom. North Carolina Util. Comm'n v. FCC*, 552 F.2d 1036 (4th Cir.), *cert. denied*, 434 U.S. 874 (1977); *Interstate and Foreign Message Telephone Service*, 56 FCC 2d 593 (1975), *recon.*, 57 FCC 2d 1216, 59 FCC 2d 716, 59 FCC 2d 83 (1976); *Telerent Leasing Corp.*, 45 FCC 2d 204 (1974), *aff'd sub nom. North Carolina Util. Comm'n v. FCC*, 537 F.2d 787 (4th Cir.), *cert. denied*, 429 U.S. 1027 (1976).

[1006] *See Bell System Tariff Offerings*, 46 FCC 2d 413, *aff'd sub nom. Bell Tel. Co. of Pennsylvania v. FCC*, 503 F.2d 1250 (3rd Cir. 1974).

[1007] *See MTS/WATS Market Structure*, 93 FCC 2d 241, 261, *modified on recon.*, 97 FCC 2d 682 (1983), *modified on further recon.*, 97 FCC 2d 834, *aff'd in relevant part sub nom. National Ass'n of Reg. Util. Comm'rs*, 737 F.2d 1095 (1984).

The requirement in the AT&T Consent Decree that the BOCs provide all interexchange carriers with local exchange access that is "equal in type, quality, and price to that provided to AT&T" has greatly increased the pro-competitive effects of the FCC's mandatory interconnection decision. See Modification of Final Judgment, Sec. II(A) and App. B, *United States v. AT&T*, 552 F. Supp. at 227, 232-234. Another antitrust consent decree imposes similar "equal access" obligations upon GTE. *See United States v. GTE Corp.*, 603 F. Supp. 730 (D.D.C. 1984). Finally, the FCC has ordered the other independent telephone companies to provide "equal access" for interexchange carriers, albeit on a more extended schedule than was imposed on the BOCs and GTE. *See MTS and WATS Market Structure*, 100 FCC 2d 860 (1985).

[1008] *See The Need To Promote Competition and Efficient Use of Spectrum for Radio Common Carrier Services*, 59 Rad. Reg. 2d 1275 (1986), *clarified*, 2 FCC Rcd 2910 (1987), *recon.*, 4 FCC Rcd 2369 (1989); *Cellular Communications Systems*, 86 FCC 2d 469, *recon.*, 89 FCC 2d 58 (1981), *further recon.*, 90 FCC 2d 571 (1982).

The FCC is now exploring mandatory interconnection as a mechanism for creating greater opportunities for competitive provisioning of the federally-regulated interstate access services offered by LECs. Thus, the FCC recently instituted a rulemaking that proposes to require that all "Tier 1" LECs provide expanded interconnection to all third parties for provision of interstate special access services (*i.e.*, private line connections between customer premises and interexchange carriers).[1009] The FCC has also solicited comment on whether it should initiate another rulemaking to order similar interconnection to permit competitive provisioning of interstate switched access services.[1010] NTIA strongly supports the FCC's initiatives in both of these areas.[1011]

However, much of the activity regarding local exchange interconnection is taking place at the state level. In 1989, the New York Public Service Commission (PSC) ordered New York Telephone (NYT) to interconnect with alternative local exchange carriers at or near an NYT switching office for the carriage of intrastate private line traffic within the New York City LATA.[1012] In the PSC's words, "[a]llowing liberal interconnection with the local exchange network generally fosters competition and will likely provide more effective and efficient carrier access service."[1013] We also understand that local exchange interconnection is one of the issues that the California Public Utilities Commission is considering in ongoing proceedings on how to introduce competition into intrastate telecommunications services markets.[1014]

LECs themselves have become more willing to allow alternative local telecommunications providers to interconnect with the LECs' local networks. As early as 1986, New Jersey Bell voluntarily negotiated a central office interconnection agreement with Teleport Communications (Teleport).[1015] United Telecommunications has provided central office interconnection to a firm in Florida.[1016] After the New York PSC ordered NYT to interconnect with competing local carriers in New York City, NYT's parent, NYNEX agreed to permit Teleport to interconnect with all of NYNEX's central offices in New England.[1017] Illinois Bell recently agreed to allow Teleport to interconnect with several Illinois Bell switching offices in Chicago.[1018] Finally, Pacific Telesis has agreed to allow Teleport to interconnect with PacTel central offices in Los Angeles and San Francisco.[1019]

[1009] *See Expanded Interconnection with Local Telephone Company Facilities*, 6 FCC Rcd 3259 (1991). Tier 1 LECs are "those exchange carriers with more than $100 million in annual interstate revenues for a sustained period of time." *Id.* at 3259 n.1.

[1010] *See id.*

[1011] *See* Reply Comments of the NTIA in CC Docket No. 91-141 (filed Sept. 20, 1991).

[1012] *See Regulatory Policies for Segments of the Telecommunications Industry Subject to Competition*, 103 PUR4th 1, 13-15 (N.Y. Pub. Serv. Comm'n 1989) (*New York Interconnection Order*). Teleport Communications and Metropolitan Fiber Systems completed interconnection agreements with NYT in 1990.

[1013] *Id.* at 14.

[1014] *See* Comments of California; *ALTS Report, supra note 968*, at 2.

[1015] *See ALTS Report, supra note 968*, at 2; *Expanded Interconnection with Local Telephone Company Facilities*, 6 FCC Rcd at 3261 n.12.

Thus, the notion of local exchange interconnection is steadily gaining support around the nation. Moreover, interconnection would be an important step towards further unbundling of local exchange networks. NTIA has consistently stated that such "fundamental unbundling" can promote both local exchange competition and economic efficiency.[1020] We also believe that fundamental unbundling would be a logical and reasonable extension of the "open network architecture" (ONA) concept adopted by the FCC in its Computer III proceeding.[1021] Thus, in August 1989, NTIA recommended that the FCC initiate proceedings to "begin a careful evaluation of the prospects for further unbundling of BOC basic network facilities."[1022] Mandating local exchange interconnection would help the FCC and state commissions gather information and experience that will better inform their policy judgments concerning when and how to implement further unbundling of local exchange networks.[1023]

[1016] *See ALTS Report*, supra note 968, at 2.

[1017] *See* Taff, *Nynex agrees to collocate alternative carriers' gear*, Network World, Dec. 12, 1990, at 2. This agreement was prompted, in part, by pressure from the Massachusetts Department of Public Utilities. *See id.*

[1018] *See* Teleport Communications Group News Release (Feb. 20, 1991). *See also* Illinois Bell Tel. Co. Illinois Commerce Commission Tariff No. 15, § 7.

[1019] *See* Comments of the NYNEX Telephone Companies in CC Docket No. 78-72, Phase I, at 22 (filed Feb. 22, 1991).

[1020] *See, e.g.*, Address by Janice Obuchowski, Administrator, NTIA, to the George Washington University School of Government & Business Administration Conference on Bringing Competition to Telecommunications (Apr. 9, 1991), at 8 (Obuchowski Speech). *See also Filing and Review of Open Network Architecture Plans*, 4 FCC Rcd 1, 42 (1988) ("More fundamental unbundling could be a socially desirable goal".) NTIA has also recognized that fundamental unbundling would require substantial reform of existing pricing policies. *See* Obuchowski Speech at 3-7. We discuss this important issue below.

[1021] *See Amendment of Section 64.702 of the Commission's Rules and Regulations (Third Computer Inquiry)*, 104 FCC 2d 958 (1986), *recon.*, 2 FCC Rcd 3035 (1987), *further recon.*, 3 FCC Rcd 1135 (1988), *vacated and remanded sub nom. California v. FCC*, 905 F.2d 1217 (9th Cir. 1990).

[1022] Comments of NTIA in CC Docket No. 88-2, Phase I, at 9 (filed Aug. 11, 1989). Noting that several state commissions were then examining the issue, we suggested that the FCC consider such issues as the costs, benefits, technical feasibility, and timing of further unbundling, the potential market demand for unbundled network capabilities, and the effects of further unbundling on local exchange competition and universal service. *See id.* at 8 n.17, 9.

Given the potential boost that interconnection can provide for local exchange competition, it is time for regulators to complete that process. Thus, we applaud the FCC's proposal to order local exchange interconnection to promote competition in the provision of interstate special access services. We also urge the FCC to commence expeditiously further proceedings to explore local interconnection as a means of fostering competitive provisioning of interstate switched access services, as well. Finally, we strongly urge state commissions that have not already done so to begin proceedings to evaluate mandatory local exchange interconnection and to address the policy issues (especially pricing issues) that its implementation would raise.

Regulatory action with respect to local exchange interconnection should be guided by two fundamental principles.[1024] First, while regulators should require interconnection, they should not attempt initially to develop a standard interconnection agreement. There is likely to be considerable variation from state to state, community to community, and, perhaps, provider to provider with regard to network design, space availability, and technical requirements. As a result, the terms and conditions of a mutually acceptable interconnection agreement (*e.g.*, with regard to price, ownership of the interconnecting facilities, or the technical characteristics of interconnection) will likely vary as well.[1025]

However, we recommend that, after a reasonable period of initial experimentation with privately negotiated agreements, regulators require the tariffing of interconnection agreements in order to facilitate regulatory review and, thus, ease the regulators' task of detecting and remedying unreasonable or discriminatory rates, terms, or conditions. As importantly, tariffing could also be a valuable tool for promoting technical standardization, if that is deemed necessary. In this regard, we note that the New York PSC's interconnection order required NYT to proceed by tariff.[1026] Additionally, the interconnection agreement for Chicago between Teleport and Illinois Bell has been embodied in a tariff.[1027] Similarly, the FCC requires tariffed interconnection arrangements for interexchange services and enhanced services.

[1023] *See* Obuchowski Speech, *supra* note 1020, at 2.

[1024] In its recent decision to abolish the current duopoly market structure, the British government took into account similar concerns in discussing the interconnection issue. In general, it favored limiting the government's role in mandating the terms of interconnection agreements, while ensuring that incumbent operators not use interconnection as a way to frustrate competition. *See Duopoly Review, supra* note 713, at 54-55. With respect to interconnection between cable operators and the incumbent network operators in particular, the government recommended that cable operators be permitted to seek a determination of interconnection terms from the government if they failed, after due diligence, to reach a commercial agreement with a trunk operator. *Id.* at 33.

[1025] For example, although Teleport Communications has interconnection agreements in New York, Illinois, and California, we understand that those agreements are not identical.

On the other hand, requiring interconnection agreements to be tariffed immediately may limit a LEC's ability to negotiate different, but still mutually satisfactory, agreements with other alternative local telecommunications providers. This problem could be alleviated, at least in the early stages of local exchange interconnection, by requiring interconnection agreements to be treated as a variation of the "Individual Case Basis" tariffs that LECs may now file, which could give LECs and alternative providers some flexibility with respect to price, terms, and conditions. As experience is gained concerning the requirements and contours of interconnection, regulators could decide at a future time to require that all interconnection agreements be embodied in tariffs. However state and federal regulators decide to proceed, the availability of some formal review mechanism is necessary to ensure that interconnection agreements are reasonable and nondiscriminatory and preserve the interoperability of the nationwide telecommunications system.

Second, while a regulator should afford the parties flexibility, at least initially, to establish the terms and conditions of their interconnection agreement, it should nevertheless establish procedures to ensure that both parties negotiate in good faith. For example, the regulator should consider requiring that the negotiations be concluded within a time certain. At the end of that period, the regulator should be prepared to step in, at the request of any party, to resolve remaining disagreements. To minimize regulatory involvement in this process, the regulator could create incentives for the parties to limit areas of disagreement before the regulator enters the negotiation. Thus, the regulator could declare at the outset that, in resolving disputes, it will choose only between the last offers made by the parties.

To the extent that certain LEC services are now overpriced, local exchange interconnection will tend to make such overpricing unsustainable. If the LEC services remain overpriced, alternative providers may be able to replace the LEC facilities that support those services with their own facilities, whether or not the alternative providers' facilities can be furnished at less cost. If the LECs are allowed to reprice their facilities, as they should be,[1028] existing subsidies will not remain. As we discuss in greater detail in Chapter 7, increased competition and repricing of local exchange services can advance social policy goals, such as universal service, through lowered prices and increased consumer choice. However, to the extent that regulators relied on today's inefficient subsidy structure in seeking to achieve such goals, those subsidies will have to be replaced in the short term. Accordingly, regulators should have the discretion to require any party receiving local exchange interconnection to pay a fee that contributes to the support of those subsidies deemed necessary to further universal service goals.[1029]

[1026] *See New York Interconnection Order,* 103 PUR4th at 14.

[1027] *See* Illinois Bell Tel. Co. Tariff Illinois Commerce Comm'n No. 15 (issued Feb. 20, 1991).

Liberal interconnection policies could open up a vast potential for competition in the local exchange services market. With the development of competition, the local exchange market could eventually resemble the interexchange services market in that consumers could choose from a variety of providers to satisfy their local communications needs. At the same time, competing providers could, through interconnection, rapidly extend their service areas, upgrade their facilities, and deploy new services.

To be sure, full realization of this vision will require policymakers to address and resolve a number of difficult issues, including how to ensure interoperability among the various competing networks. Moreover, to make local competition truly effective, regulators should explore ways to permit customers to select, access, and move among the various alternative providers with a minimum of inconvenience. For example, to enhance customers' ability to change local exchange providers, regulators should explore the possibility of giving customers greater control over their telephone numbers, by allowing them to take that number with them when they change providers.[1030] Some observers contend that the current lack of "number portability" will be a major impediment to the growth of local exchange competition.[1031] On the other hand, authorizing greater customer control over telephone numbers could stimulate development of UPT, a service that would allow an individual to initiate and receive calls with a single telephone number at any terminal, irrespective of geographic location. NTIA recommends that federal and state regulators explore the costs and benefits of number portability, as a tool to fully achieve the potential benefits of local exchange competition that local interconnection will set in motion.

[1028] *See* Obuchowski Speech, *supra* note 1020, at 3, 4, 6.

[1029] *See New York Interconnection Order,* 103 PUR4th at 14; MFS Petition, *supra* note 999, 1003, at 76-77. We think that the decision to require such a contribution should be discretionary only because the regulator may find other mechanisms for regenerating the needed subsidies.

[1030] The British government plans to introduce number portability under its new open competition policy. *See DTI Press Release, supra* note 973, at 6.

[1031] *See, e.g.,* Reply Comments of Teleport Communications Group at 3; Director General of Communications, British Office of Telecommunications, *Numbering for Telephony Services into the 21st Century* 10 (July 1989).

b. LEC Pricing Reform

As discussed below, the current pricing structure for local exchange services is replete with subsidies flowing from service to service.[1032] Whether or not this pricing structure was ever desirable as a matter of policy,[1033] there is a growing consensus that it cannot and should not be sustained in an increasingly competitive market environment.[1034] While NTIA strongly supports the introduction of competition in all telecommunications markets (including the local exchange), we recognize that, to ensure that competitive entry is welfare-enhancing, the pricing structure must send the right signals to consumers, incumbents, and entrants alike.

In NTIA's view, the fundamental component of an efficient, welfare-maximizing pricing policy is that the price of any service should reflect the costs of providing that service. Cost-based pricing will ensure that competitive entry into any telecommunications service market is, in fact, economically efficient. Pricing an incumbent's services above their relevant costs will attract entry from other providers, even if their costs are higher than the incumbent's, so long as the entrants' costs are lower than the regulated rate. In this case, the competition from the higher-cost entrants is "artificial" and represents an inefficient use of scarce resources. On the other hand, setting the incumbent's prices below cost will deter entry by firms whose production costs are lower than the incumbent's, but higher than the prevailing price. Consumers would therefore be denied an opportunity to take services from a firm that could provide those services at a lower cost to society.

[1032] *See supra* notes 1057-1067 and accompanying text.

[1033] Several economists have estimated that the welfare losses associated with the existing pricing structure can be measured in the billions of dollars annually. *See, e.g.*, Griffin, *The Welfare Implications of Externalities and Price Elasticities for Telecommunications Pricing*, 64 Rev. Econ. & Stat. 59 (1982) (estimated annual welfare loss of $1.5 billion in 1975 dollars); Perl, *Welfare Gains From Cost-Based Telephone Pricing* (June 19, 1986) (welfare gains from moving to economically efficient pricing estimated at $5.5 billion annually in 1984 dollars). Eliminating these welfare losses would have the same effect as giving the public an equivalent amount of additional income. *See Kahn and Shew, supra* note 918, at 209.

[1034] *See, e.g.*, Comments of California at 9; Comments of New York PSC at 9; Comments of BellSouth Corp., App. H at 9; Reply Comments of GTE Service Corp. at 14; *Kahn and Shew, supra* note 918, at 192-93.

At the same time, cost-based pricing will also promote efficient infrastructure investment. As one commenter points out, a firm will be reluctant to upgrade its network with new technology if regulated rates do not allow it to recover the costs of that investment.[1035] Conversely, pricing services above their relevant costs will inevitably depress demand and, thus, reduce firms' incentives to make network investments that can make such services available.[1036]

Additionally, regulated LECs must be allowed to respond to competitive entry.[1037] Thus, when a regulator determines that workable competition exists in a particular service market, it should remove rate and entry regulation for all providers of that service, including the LECs.[1038] Second, where competition is emerging, but not fully effective, regulated firms must be given flexibility to change their rates to meet their new rivals,[1039] so long as regulated rates remain above their costs. Both of these policies are necessary to ensure that any firm's success in the marketplace is due to superior performance, rather than to the regulatory burdens borne by some or all of its rivals.

NTIA recognizes that, when partially competitive services remain regulated, according firms pricing flexibility with respect to those services raises the potential that the firms may be able to subsidize those competitive services from their monopoly, or less competitive, services. We think, however, that these concerns can be addressed without denying regulated firms the flexibility that they will need to respond effectively to new entrants.

For example, in its price cap plans for both AT&T and the LECs, the FCC has employed a combination of service "baskets" and rate bands to accord those firms some pricing flexibility while, at the same time, limiting the likelihood that reductions in rates for competitive services can be funded by increases in the rates for less competitive services.[1040] Similarly, a number of state legislatures and state regulatory commissions have begun to segregate LEC services into, typically, three broad categories—fully competitive, partially or emerging competitive, and monopoly—subject to increasingly stringent regulatory oversight.[1041] Such separation of services (as well as the costs associated with providing those services) can mitigate concerns that essential pricing flexibility for regulated firms will not be followed by undesirable cross-subsidization.

[1035] *See* Comments of Northern Telecom at 88-89.

[1036] *See id.* at 89. *See also* Comments of Southwestern Bell Corp. at 53-55.

[1037] The establishment of depreciation rates that reflect the shortened economic life of most network equipment will, in many cases, require adjustments in the services rates that are based, in part, on those depreciation rates. LECs should, of course, have flexibility to adjust their rates to accommodate these more rational depreciation policies.

[1038] We are, of course, aware of the difficulties inherent in trying to determine the point at which any particular market is workably competitive, so that regulation can be eliminated.

[1039] *See Back to the Future, supra* note 931, at 193.

[1040] *See LEC Price Cap Order*, 5 FCC Rcd at 6810-6814; *AT&T Price Cap Order*, 4 FCC Rcd at 3051-3067.

c. Implications for Standards Activities

Standardization issues growing out of local exchange competition, while they may not differ fundamentally from those dealt with in other contexts, could generate needs for additional standards, particularly with respect to any interconnection and interoperability goals expressed by the FCC, NTIA, or state regulators.[1042]

Any goals mandated by these bodies involving standards development must be articulated clearly enough to guide participants in standards development activities. Drawing upon the logic of our interconnection discussion, after articulating goals, policymakers should assign the development of standards to the appropriate private bodies. The FCC, as the expert regulatory agency, and NTIA, as the Executive branch policy and technical agency, should take particular responsibility for this activity. Because of their oversight of the national network, the FCC and NTIA should monitor standards activities in this area, to ensure that nationwide uniformity of standards occurs when appropriate. In this role, the FCC and NTIA should consult with the states, through a joint conference or otherwise, to discuss standards progress, in the context of infrastructure development and universal service.

[1041] *See* Bell Atlantic, *Regulatory Reform Update* (Oct. 19, 1990) (states involved include Colorado, Minnesota, Missouri, South Dakota, New Jersey, and Virginia).

[1042] The proliferation of telecommunications networks that will likely occur in a competitive market environment will also increase the need for cooperation and consultation between and among various network providers. For example, to facilitate interconnection and interoperation of different networks, and to prompt seamless deployment of new services and features by different providers, there may need to be extensive planning and coordination among the various providers in developing and deploying their networks. *See* Comments of USTA at 35-36. *See also* Comments of Leland Schmidt at 4-6. Further, greater sharing of network facilities may be needed to ensure that smaller and more rural providers can offer their customers the same range of services and capabilities that are available to customers of larger telecommunications providers. *See* Comments of TDS at 74-75. As a rule, such joint planning and "infrastructure sharing" arrangements should be encouraged, to the extent that they do not impede competition. When appropriate, the relevant government authorities should consider developing guidelines indicating which sorts of joint planning and infrastructure sharing agreements will be deemed permissible.

The growth of competition will increase the number of players that depend upon standards for designing and operating their systems. Under such conditions, more players will also be interested in participating in standards development activities. The continuing critical importance of standards and the prospect of additional participants in the process will require greater diligence by standards organizations to ensure that their practices remain reasonable, fair, open, and efficient. In the event that current practices should become unworkable, the industry has sufficient means to initiate necessary modifications that conform to standards process accreditation principles.

Chapter 7 Universal Service

I. INTRODUCTION

This report's most fundamental policy theme—to extend the benefits of competition to all segments of the telecommunications marketplace (including video services and local exchange services)—was developed in Chapter 6. In this chapter, we apply that competitive analysis to a fundamental tenet of U.S. telecommunications policy, the long-standing commitment to "universal service."[1043] As described in the Notice,[1044] "universal service" now means the provision of a basic level of telephone service to all, at affordable rates.

We suggested in the notice that the present meaning of "universal service" may be too limited as the U.S. telecommunications infrastructure continues to develop. We asked for comments on (a) whether the basic service components to be offered universally should be different from the "basic voice package" now commonly offered (and whether these new components should be offered as optional features), and (b) how the redefined service should be made universally available and affordable. In particular, we are concerned with the relationship between such issues and infrastructure development.

The importance of telecommunications with respect to the economic and social well-being of the U.S. populace is incontrovertible.[1045] Telecommunications represents a powerful means to improve the quality and broaden the scope of education and health care services to all corners of this nation. Moreover, it holds great promise for those Americans with disabilities to experience opportunities otherwise beyond their grasp. The possibilities for a general betterment of life clearly exist—but full realization of these possibilities necessarily depends on ubiquitous access to the Information Age capabilities demanded by users.

[1043] *See* Pressler and Schieffer, *A Proposal for Universal Telecommunications Service*, 40 Fed. Com. L.J. 351, 353 (1988) (*Pressler & Schieffer*).

[1044] Notice, 55 Fed. Reg. at 816, para. 134.

[1045] *See supra* Chapter 3.

As we discuss in detail in this chapter, "universal service" should be redefined in order to preserve its equity goals. The FCC and the states should interpret the universal service mandate of Section 1 of the Communications Act as encompassing services more advanced than the traditional "basic voice service." We would currently include in this expanded concept of "universal service" such "advanced" fundamental capabilities as touchtone dialing, ready access to emergency communications (*e.g.*, 911 services), improved services for the hearing-impaired, and equal access to IXCs.

The FCC and the states should use increased competition to further universal service goals through what we call Advanced Universal Service Access (Advanced USA)—so that users throughout the country have the opportunity to obtain the same types of telecommunications services that are offered through public networks by carriers or others. Today that might include the ability to access various custom calling features, facsimile services, and enhanced or information services.[1046] In the near future, as SS7 becomes fully implemented, it could include some form of "caller ID" (*i.e.*, calling number identification) and selective call forwarding. Conceivably, Advanced USA could allow on-line, at home access to the Library of Congress, to the extent that its resources are available in electronic format.[1047]

Such advanced offerings should generally be available on an optional basis, according to the demand expressed for them.[1048] However, when a service incurs little or no identifiable separate cost (such as touchtone), its price should be set at or near zero and included as part of the basic service package. With other services, we recommend as a general matter that prices be based to the degree possible on relevant "costs." Either competition or a well-crafted incentive regulation scheme will accomplish this objective.

[1046] This expanded universal service concept does not require a redefinition of the FCC's regulatory categories of "basic" and "enhanced" services, but would encompass any new form of basic service should such redefinition occur over time due to advances in technology. Accordingly, we are not suggesting that the scope of regulated services be expanded, but that all Americans have comparable ability to access certain sets of services, basic or otherwise, that may be reached through telecommunications networks.

[1047] Because this report does not focus on information policy, we do not make a recommendation on when such a service should be available.

[1048] We note that such services need not be supplied solely through the public switched network or even competing telecommunications networks. For example, CPE now provides many advanced features at low, competitive prices, and presumably will continue to do so in the future.

Strict adherence to marginal cost pricing is not essential since, in practice, marginal costs may be difficult to determine and some reasonable level of contribution to common costs is acceptable. What is important is that regulators not force these services to be priced substantially above their true costs, as is frequently the case now, in order to permit below-cost pricing of other services. Such inflated pricing of these advanced capabilities would be both economically inefficient, since it would distort the demand and supply incentives for these new (and presumably price-elastic services), and inequitable, since it would deny less affluent citizens the opportunity to use them.

Advanced USA to the public switched network will be even more important in the future in providing economic and social opportunity to all Americans. For economic development purposes, individuals and small businesses should be able to rely on the public switched network for many of the same types of options and services that larger corporations obtain through private networks. Similarly, "social" services, such as health care and applications like telecommuting and services for the disabled, rely on the public network. A major focus of our policy recommendations in Chapter 6, as well as this chapter, is to ensure that government laws and regulations are not hampering the development of our public networks.

These pro-competitive policy recommendations are superior to current monopoly-based policies in furthering our advanced universal service goals. Indeed, increased competition in telecommunications markets, including increased entry into local exchange markets, will help the achievement of these goals by spurring innovation in services and reducing prices that most customers would otherwise pay. This has been the case in the CPE and long distance markets, and we expect that competition in local exchange service will, on an overall basis, eventually have similar salutary results.

To the extent that such competition does not develop in certain service or geographic segments of the local exchange market, or develops in ways that implicate universal service goals, some limited forms of subsidy for particularly affected users might be needed to keep their rates acceptably low. Where such subsidies are found to be necessary, they should not take the form of the unfocused, inefficient, and complex systems of hidden cross-subsidies that now permeate the U.S. telecommunications rate structures. Nor should they be designed to provide subsidies for generalized below-cost pricing in order to "promote" deployment of one or more "advanced" services. Rather, any such subsidies should be narrowed and carefully targeted to those users that might otherwise have to forego telephone service, such as lower income individuals and people with disabilities that prevent them from using conventional telecommunications services (*e.g.*, the hearing-impaired).[1049] Ideally, those subsidies should be funded through explicit revenue-raising mechanisms, such as either a "universal access" surcharge or general tax revenues. We discuss these recommendations below. In endorsing Advanced USA, we believe that the goals of equity and efficiency reinforce each other—that the fundamental fairness of permitting all U.S. residents to communicate with each other at an affordable cost will also aid in the continued economic development of the United States and achievement of a universal information network.

We describe first the genesis of the universal service concept and its historical importance to this country in assuring affordable, ubiquitous communications among the American people.

II. THE HISTORICAL COMMITMENT

"Universal service" as a public policy has evolved with telephony from its earliest days. Interestingly, although the universal service concept has long been a general policy goal in the United States, the mechanism now in place to finance it is relatively new. As a *de facto* monopolist for voice services because of the Bell telephone patent in the late 1800s, American Bell (the predecessor to AT&T and the Bell System) was able to charge very high prices for its offerings. The company primarily marketed its services to businesses in the centers of major cities, initially as an adjunct or "feeder" to telegraph service; those inhabiting small towns and rural areas remained largely unserved.[1050]

With the expiration of the Bell Company patents in 1893 and 1894, entrepreneurs formed hundreds of "independent" telephone companies, primarily in rural areas but increasingly in competition with the Bell System in urban areas. By 1902, 1,002 out of the 1,051 incorporated cities in the United States with a population greater than 4,000 had telephone service. In 45 percent of the wired cities, both Bell and independent entities provided service.[1051] By 1907, the Bell System owned only 51 percent of the nation's telephone "stations" and earned an eight percent return, less than one-fifth of its rate of profitability during its patent monopoly.[1052] According to one industry observer, this dramatic decrease in Bell's market power largely resulted from the company's failure to lower prices to reasonable levels, which could have attracted small business and residential customers, and to expand services to other than major urban centers following the expiration of its patent monopoly.[1053] Although "universal service" was not an explicit component of U.S. telecommunications policy at that time, the actual achievement of universal service goals—*i.e.*, the broad geographical availability of telephone service at reasonable rates—was advancing much more rapidly under competition than it ever had under monopoly.

[1049] *See supra* notes 360-364 and accompanying text.

[1050] *See Brock, supra* note 355, at 89-109.

[1051] *See* C. Phillips, *The Regulation of Public Utilities* 684 (1988).

[1052] *See* Trebing, *Telecommunications Regulation—The Continuing Dilemma*, in *Public Utility Regulation* 95 (K. Nowotny, D. Smith, and H. Trebing eds. 1989) (*Trebing*).

In 1907, public figures such as Governor Charles Evans Hughes of New York and Senator Robert M. LaFollette of Wisconsin endorsed the notion of state utility commissions regulating a single provider that would be obliged to supply end-to-end service to all requesting service in a given geographic area.[1054] AT&T (the parent holding company of the Bell System) actively supported these initiatives, asserting that a regulated monopoly could provide better and cheaper service to customers than either competition or government ownership. It began actively advocating what it considered to be the optimal structure of the telephone business: "one system, one policy, universal service."[1055] The independent telephone companies joined the Bell System in supporting regulation over competition, claiming the latter was "detrimental to the public welfare."[1056] As a result of these efforts, laws providing for telephone regulation were enacted at both the state and federal levels. Between 1907 and 1913, 30 states established PUCs to oversee, among other things, the activities of local telephone companies, and Congress amended the Interstate Commerce Commission Act in 1910 to extend the ICC's jurisdiction over interstate telephony and give it the authority to review the reasonableness of telephone (and telegraph) rates.

[1053] Brock, *supra* note 355, at 123-125.

[1054] *See Public Regulation of the Telephone Company was a Long Evolution (Replaces Competition)*, AT&T News, Mar. 10, 1976, at 2.

[1055] *AT&T 1910 Annual Report*. *See also Trebing*, *supra* note 1052, at 95. Professor Dordick suggests that AT&T management, led by Theodore Vail, first conceived of universal service as an idea to have AT&T interconnect local exchanges of disparate telephone systems. As a result, the initial emphasis of the universal service concept was on service availability to all geographic areas rather than to all possible subscribers. Only later did Vail stress service to subscribers. Dordick argues further that Vail used the latter concept as a means to forestall competitors and "sell his version of a national telephone monopoly." *See* Comments of Herbert Dordick at 19.

[1056] *Brock*, *supra* note 355, at 159.

In practice, carriers, rather than public policymakers, largely dictated the subsidy pattern in telephony during much of the first half of this century.[1057] Prior to the 1930s, the Bell System adopted and implemented a "board-to-board" theory of "jurisdictional separations"[1058] that assigned the total cost of subscriber station equipment, local distribution plant, and local exchange switching equipment to local exchange rates. Bell included only toll switching equipment and interexchange plant in its toll costs and rates.[1059] In essence, the process assigned no exchange plant costs to the toll operations.

The Supreme Court's *Smith v. Illinois Bell* decision in 1930 rejected the "board-to-board" principle.[1060] The Court concluded that the proper basis for setting rates and separating plant would assign a portion of exchange plant costs to both local and toll rates. However, the Bell System did not acknowledge the applicability of this principle, called the "station-to-station" method, to its interstate rates until 1943, and did not fully implement the requisite tariff changes for several more years.[1061] Thus, interstate toll services generally bore no local exchange costs until 1950.

Concurrently, the FCC pressed for and achieved a series of rate reductions for interstate calls. Between 1935 and 1950, the FCC accomplished ten rounds of rate decreases,[1062] and in the 1940s, developed a nationwide averaged interstate toll rate structure under which users in rural areas and cities paid the same amount for interstate toll calls of equal duration, time-of-day, and distance.[1063]

Intrastate toll rates often were substantially higher than the FCC-regulated interstate rates because of different pricing policies. This disparity caused states to begin taking aggressive actions to transfer some intrastate costs to interstate toll services through the jurisdictional separations process.[1064] However, it was not until the 1971 "Ozark Plan" recommended by a Federal-State Joint Board and adopted by the FCC, that the separations process resulted in the assignment of a significant and growing proportion of non-traffic-sensitive local loop costs to interstate toll operations. For example, the interstate assignment doubled from 12 percent in 1967 to 24 percent in 1979.[1065] This percentage eventually grew to 26 percent nationwide in 1981, when the Joint Board and the FCC moved to curb the rise by freezing a portion of the underlying separations formula.[1066] Since all costs assigned to the interstate jurisdiction were recovered in toll rates, the result of the separation process was that, beginning in the 1970s, interstate calling tended to subsidize local service. Since the early 1980s, however, regulators have sought to reduce the subsidy burden borne by interstate toll rates through changes in the separations process and the implementation of subscriber line charges by the FCC.[1067]

[1057] *See id.* at 301-302; R. Gabel, *Development of Separations Principles in the Telephone Industry* Chapter 2 (1967) (*Gabel*).

[1058] Separations is the regulatory process whereby costs are allocated between the interstate and intrastate jurisdictions. *See* L. Johnson, *Competition and Cross-Subsidization in the Telephone Industry* (1982).

[1059] *See Gabel, supra* note 1057, at 15-16.

[1060] *Smith v. Illinois Bell Tel. Co.*, 282 U.S. 133 (1930).

[1061] *See Gabel, supra* note 1057, at 25, 27.

[1062] *See Trebing, supra* note 1052, at 96.

[1063] *See, e.g., Domestic Study, supra* note 775, at 144. Although such nationwide averaging did not initially apply to Hawaii and Alaska, these states gained full MTS/WATS rate integration with the mainland in January 1985 and January 1987, respectively.

In addition to the regulatory activities discussed above, the Rural Electrification Administration (REA) was authorized in 1947 to provide low-cost loans to rural telephone companies and cooperatives. This was necessary because, in the period of monopoly regulation from 1920 to 1940, in contrast to the early explosive growth of telephone service under competition, the number of farms with telephones had declined.[1068]

[1064] *See Trebing, supra* note 1052, at 96; *Gabel, supra* note 1057, at Chapters V and VI.

[1065] *See, e.g.*, Remarks of William F. Baxter, Assistant Attorney General—Antitrust, U.S. Department of Justice, before the Practicing Law Institute 6-10 (Dec. 8, 1983).

[1066] *See id.* at 6. At the time of the "freeze" of the subscriber plant factor (SPF), the proportion varied among individual jurisdictions, with some substantially exceeding the nation's 26 percent (*e.g.*, the District of Columbia's 40 percent figure).

[1067] Subscriber line charges are monthly flat-rate charges directly assessed to end users that recover a portion of the interstate share of local exchange costs. These charges are currently capped at $6.00 per month for business lines and $3.50 per month for residential lines. *See MTS and WATS Market Structure*, 2 FCC Rcd 2953, 2957 (1987); *MTS and WATS Market Structure*, 97 FCC 2d 682, 695 (1983); 47 C.F.R. § 69.105(d) (1990). The implementation of subscriber line charges allowed substantially lower rates for interstate toll calls.

[1068] *See* Office of Technology Assessment, U.S. Congress, *Rural America at the Crossroads: Networking for the Future*, OTA-TCT-471, at 64 n.21 (Apr. 1991) (*OTA Rural Report*).

III. UNIVERSAL SERVICE AND INFRASTRUCTURE TODAY: COPING WITH AN EVOLVING PUBLIC POLICY

A. BACKGROUND

One rationale for traditional "universal service" policies is based on simple and compelling equity concerns—that all Americans should be able to communicate with each other through telephone at reasonable prices and on an approximately equal footing.[1069] Wynns describes this motivation for universal service as a perception that telephone service is essential to bind U.S. society together.[1070] Advocates of this theory draw parallels between the concept of universal service and the nation's highway system as being critical to the well-being of the populace. However, unlike our national highway system, our national telecommunications system was not built by government. Rather, public policies promoting universal service, as implemented in regulations and statutes, encourage telecommunications common carriers to make their services broadly available while ensuring that the services are affordably priced. For example, in addition to the pricing policies already discussed, Section 201 of the Rural Electrification Act authorizes REA's Administrator to make loans so that telephone service will be made available to the widest practical number of rural users without regard to their geographic location.[1071]

Another rationale for universal service focuses in part on economic development. Recognizing the importance of telecommunications, agencies such as REA use grants and low interest loans to stimulate development in rural areas.[1072] Moreover, economists have explained the role of universal service, such as subsidized telecommunications development in high cost areas, in terms of addressing externality concerns.[1073]

[1069] *See, e.g.*, Pressler & Schieffer, *supra* note 1043, at 353.

[1070] Congressional Budget Office, U.S. Congress, *The Changing Telephone Industry: Access Charges, Universal Service, and Local Rates* 27 (June 1984).

[1071] *See* Comments of REA at 12.

[1072] *See id.* at 3.

[1073] The traditional externality argument relating to the network has been summarized as follows:

> A positive externality occurs when consumption of a product by one person directly increases the economic welfare of others. The value to any individual of being on the telephone network depends on the availability of others to call (or be called by). In deciding whether to subscribe to telephone service, an individual may not take the value to others of his own presence on the network fully into account. Hence, in certain circumstances it could conceivably be socially efficient to subsidize access to the telephone network.

(continued...)

Federal and state agencies have undertaken the pursuit of widely available, reasonably priced telecommunications service through a complex system of cost support programs, averaged rates, and area-wide service obligations.[1074] It is somewhat ironic that, even in light of the contributions that competition made in initially establishing telephone service in the United States, these elaborate mechanisms were developed as part of an industry model based on a theory of natural monopoly and a practice of government-sanctioned monopoly through exclusive franchises and other regulatory barriers to competition. Moreover, especially during the early development of monopoly telephone services, regulators found it necessary to order companies to extend service to previously unserved areas, even though, under competition, service had been expanding quite rapidly into such areas.[1075]

B. THE STATE OF UNIVERSAL SERVICE

1. The Record

Those attempting to gauge the state of universal service development in the United States commonly cite telephone service subscriber "penetration" statistics as evidence.[1076] Commenters disagree, however, about the adequacy of telephone penetration among U.S. households. Ameritech, pointing to a 1989 average penetration figure of 95.4 percent in its region, suggests that "there is no geographic area [served by it] in which telephone

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1073 (...continued from preceeding page)

Gordon and Haring, *The Effects of Higher Telephone Prices on Universal Service*, FCC Office of Plans and Policy Working Paper Series No. 10, at 7 (Mar. 1984). Gordon and Haring go on to argue that there is little evidence to support this notion or to demonstrate the size of any existing externality. *See also Panzar, supra* note 809, at 3.

A second type of consumption externality that may be relevant here is the notion that the average person derives satisfaction from knowing that other people, such as relatives and friends, have access to a telephone in an emergency.

[1074] *See generally* Lavey, *The Public Policies That Changed the Telephone Industry Into Regulated Monopolies: Lessons From Around 1915*, 39 Fed. Com. L.J. 171 (1987) (*Lavey*).

[1075] A recent report states that the number of households with telephones grew more rapidly during a period of competition between Bell and independent operating companies (*i.e.*, 173 percent during 1895-1910), compared with the "monopoly" periods just before and after the interval (36 percent and 52 percent, respectively). *See Is This Man Right?*, Telephony, Dec. 31, 1990. REA loan programs have also played a key role in expanding telephone services. *See* 7 U.S.C. § 921 (1988). *See also Lavey, supra* note 1074, at 173.

[1076] As used in this report, penetration means residential subscribership, measured as a percentage of total U.S. households.

service is inaccessible to anyone who desires it."[1077] BellSouth, citing a 1990 national penetration rate of 93 percent, declares that the "achievement of universal service has been accomplished," and argues that the remaining households fail to subscribe by choice, not due to a lack of availability.[1078] According to Southwestern Bell, it has "virtually achieved what has been considered universal availability of basic service within the territory it serves."[1079] Cincinnati Bell points to a 96 percent household penetration rate in its service area.[1080] USTA argues that universal service has been substantially achieved in this country, while REA says that realization of this long-standing objective with respect to rural areas is "nearing completion."[1081]

Others are less sanguine. The Lower Mississippi Delta Development Corporation, citing a 1980 Census statistic of 11.5 percent of the households in the Delta region without telephone service, argues that "we can no longer afford to leave anyone behind."[1082] The Alliance for Public Technology urges the examination of options for improving low penetration levels for Native Americans.[1083] The National Center for Telecommunications and Information Policy asserts that the "most rudimentary forms of public telephony are far from universal in economically marginal quarters of the United States."[1084]

2. NTIA's Analysis

We briefly examine the progress that the United States has made in satisfying the traditional "universal service" goal from the perspectives of availability and affordability.

[1077] Comments of Ameritech at 61.

[1078] Comments of BellSouth Corp. at 4-6.

[1079] Comments of Southwestern Bell Corp. at 62.

[1080] Comments of Cincinnati Bell Telephone Co. at 12.

[1081] Comments of USTA at 3; Comments of REA at 2.

[1082] Comments of LMDDC at 12.

[1083] Comments of APT at 3, and App. D (citing testimony at 1990 NTIA/APT field hearings, as well as 1980 Census data).

[1084] Comments of NCTIP at 2-3.

a. Availability

Telephone penetration in this country has steadily risen over the past four decades. For example, the number of residential main telephones per 100 U.S. households increased from 61.8 percent in 1950 to 95.7 percent by 1981, an increase in excess of 50 percent.[1085] This statistic has the advantage of being relatively simple to derive, but the disadvantage of overcounting households with multiple telephone lines. Thus, as subscribers added second or third telephones lines to their residences, or established phone service to vacation homes, this statistic became increasingly less useful as an accurate measure of the percentage of U.S. households with telephone service. In order to obtain more reliable information on telephone penetration levels, the FCC requested the Bureau of the Census to include telephone penetration questions in its Current Population Survey (CPS), which is designed to collect demographic data between the decennial censuses. As a result, Census now gathers data on telephone penetration in this nationwide survey of about 58,000 households, which it conducts three times a year.[1086]

According to this Census data, the percentage of U.S. households with a telephone rose from an average of 91.6 percent in 1984 to 93.3 percent in 1990.[1087] Beneath the averages, however, is a less uniform distribution of penetration rates. For example, a state-by-state breakdown yields penetration figures in 1990 ranging from 85.8 percent (New Mexico) to 97.1 percent (Connecticut, Washington).[1088] Still, a general improvement can be seen by comparing 1990 with 1984, when the corresponding range for the 50 states and the District of Columbia was from 82.0 percent (New Mexico) to 96.2 percent (Iowa).

Other demographic comparisons also show that penetration levels differ for Americans of different income levels, ages, ethnic background, and household size, although virtually all U.S. households, regardless of size or ethnicity, exhibited higher penetration rates in 1990 than in 1984.

[1085] Tables presenting a year-by-year compilation of these statistics appear in Appendix F.

[1086] The Census Bureau did collect data on the availability of telephone service in the 1980 decennial census, which produced a residential telephone figure of 92.9 percent. However, because of concerns that the Census question could produce a positive response if members of the household could be reached through a telephone not on their premises (*e.g.*, in a neighbor's home or through a pay phone in a common area), the FCC asked the Census Bureau to include a more precise set of questions in the CPS that focused on the availability of telephone service in the home.

[1087] For a year-by-year listing, see Appendix F.

[1088] *See* Common Carrier Bureau, Federal Communications Commission, *Telephone Subscribership in the U.S.*, Table 2 (Sept. 1991) (*Telephone Subscribership*).

When penetration rates are compared with respect to ethnicity and levels of family income, it becomes evident that a substantial number of American families in the lowest income brackets (annual income less than $5,000) do not have a telephone on their premises. While this finding holds regardless of ethnic background, it is most pronounced among minorities.[1089] Lower penetration rates among minority households persists (while gradually narrowing) well into middle income ranges. The trends reflect some improvement, however. While penetration has risen by 1.5 percent for white Americans over the interval, the rates for African-Americans and Hispanic-Americans have grown by 4.4 percent and 2.2 percent, respectively.[1090]

An examination of the "age factor" shows that there is one particular group that has a very low penetration rate: young minority householders. In 1990, 66.4 percent of African-American and 67.8 percent of Hispanic households in the United States whose heads were age 16-24 had telephones in their homes, compared to penetration of 83.6 percent for white households in that age group. In contrast, telephone subscribership is highest among the elderly, as 90 percent or more of the households headed by U.S. citizens over 65 in each of these three ethnic categories have a phone today.[1091]

Based on the evidence we have marshalled, the overwhelming majority of Americans currently subscribe to telephone service. The current 93.3 percent penetration rate is this country's high-water mark for the post-divestiture period. This statistic is even more impressive in light of the fact that ten million households have been added to the U.S.

[1089] In 1990, those with lower penetration rates included all American families with annual incomes less than $5,000 (75.4 percent), and particularly the low income households comprised of African-Americans (66.1 percent), those with Hispanic backgrounds (61.1 percent), and Native-Americans (as low as 3 percent penetration on some Indian reservations). *See id.* at Table 4; Comments of APT at 3, App. D at 7.

The percentages improve for low income families as a group and for Americans of African and Hispanic origins (81.0 percent, 72.8 percent, and 66.1 percent, respectively, in 1990) when the standard becomes telephone availability, *i.e.*, whether there is a telephone either on-premises or elsewhere on which members of a household can be called. *See Telephone Subscribership, supra* note 1088, Table 4. We were unable to find the corresponding data regarding Native Americans, a recurring deficiency that we believe should be rectified in future data collection efforts.

[1090] Information concerning Native Americans is difficult to find and appears to be primarily anecdotal in nature; the data that are available suggests that this is a group that should be examined more closely with respect to its members' access to telephone service and its affordability.

[1091] *See Telephone Subscribership, supra* note 1088, at Table 4.

telephone system since the FCC/Census surveys began in November 1983.[1092] Put another way, from 1983 to 1990 the percentage of households without telephone service has decreased by over 22 percent (from 8.6 percent to 6.7 percent), while at the same time the total number of households has increased 10.4 percent (from 85.8 million to 94.7 million). Moreover, it is not clear what proportion of those who do not have telephone service actually do not subscribe by choice. Certain groups in our society, however, exhibit much lower penetration rates than the population at large.[1093] These include low income persons, and particularly minorities. In an absolute sense, the "universal service" goal has apparently not been met.

Nevertheless, the United States compares favorably to most of its major trading partners: among the "Group of Seven" countries, the United States apparently trails only Canada and France in terms of total access lines per 100 population and per 100 households.[1094] In other countries, such as the United Kingdom, there are also subgroups that exhibit relatively low penetration rates.[1095]

[1092] *See id.* at Table 1.

[1093] Other researchers have also reached the same conclusion. For example, Lavey, while characterizing a 1986 national aggregate statistic of 92.2 percent of U.S. households with telephones as almost universally available telephone service, points out that the penetration level in some states and some rural areas is significantly lower. *See Lavey, supra* note 1074, at 192.

[1094] The penetration measures that we have discussed for the United States are not available for other countries. International measures generally examine access lines per population or access lines per household. As of January 1, 1989, the ranking of the "Group of Seven" based on the number of residential access lines per 100 population is Canada (39.1 lines/ 100), France (37.7), United States (34.1), UK (32.2), Japan (29.0), and Italy (27.6). No data are available for Germany. AT&T, *The World's Telephones* Table 9 (1990). A separate analysis by British Telecom comparing number of access lines per 100 households in 1988 also shows that the United States (92.9) leads all other "Group of Seven" countries except Canada (106.2) and France (97.7). BT provided statistics in this study for Germany (90.7), the UK (86.4), and Japan (81.1), but apparently none for Italy. *See* British Telecom, *Supplementary Report* (1980) (cited in *MESA Study, supra* note 446, at Table 4).

[1095] Recently completed research found that certain British "social groups" had much lower-than-average telephone penetration levels. These groups included Northumberland coal field estates (40 percent), unfurnished tenants (66 percent), furnished tenants (45 percent), single pensioners (72 percent), and one-parent families (62 percent). The survey average was 85 percent. Central Statistical Office, *1988 Family Expenditure Survey* (Feb. 1990).

In a commentary on relative penetration rates, a British researcher recently stated that:

> extrapolating from recent growth figures for main lines per 100 population suggests that penetration in the UK is not keeping up with other countries. The British are used to being well behind North America and Scandinavia, but national pride may suffer more of a blow when people realize that the UK has been overtaken by France, FR Germany and Italy.

See Milne, *Universal telephone service in the UK: An agenda for policy research and action,* 14 Telecommunications Pol. 365 (1990).

b. Affordability

Based on data collected by the Department of Labor's Bureau of Labor Statistics and analyzed by the FCC, the price of telephone service (as measured by the consumer price index (CPI)) increased less rapidly from 1980 to 1990 than that of most CPI categories, including all goods and services, all services, food, housing, electricity, and medical care.[1096] Only the CPIs for clothing and transportation during the same period showed smaller increases than the CPI for telephone service. Indeed, from 1984, the year of the AT&T divestiture, to 1990, the price of telephone service increased 15.9 percent, which was much lower than the price increase for all goods and services of 28.3 percent.[1097]

The proportion of the average household's total annual budget represented by all telephone services remained about the same during the 1980s (1.9 percent in 1980 vs. 2.0 percent by 1989).[1098] Despite this relatively constant proportion of consumer expenditures devoted to telephone service, what consumers are getting today for their telephone-related purchases is in many respects a better value than in the past. For example, technical quality has improved,[1099] and the diversity of CPE options has dramatically increased.[1100] Consumers clearly recognize this heightened utility. Minutes of use have grown robustly in recent years, especially for interstate traffic; in 1989, interstate traffic accounted for 14 percent of total minutes of calling, an 81.8 percent increase over 1980's 7.7 percent.[1101] Perceived by many as a rarely-indulged luxury service in the past, long distance calling is now increasingly commonplace among ordinary consumers. For example, the FCC estimates that interstate long-distance calling by residential and business consumers has increased, on average, more than 12 percent per year since mid-1984, which would amount to a doubling in the volume of such calling during this period.[1102] And consumer purchases of CPE, including cordless phones and answering machines, grew by 39 percent between 1987 and 1990.[1103]

[1096] *See* Appendix F, Table F-4.

[1097] *Telephone Trends, supra* note 30, at 7, Table 4. The figures shown are simple (non-compounded) percentages.

[1098] *See id.*, at 14, Table 10.

[1099] *See supra* notes 679-681 and accompanying text.

[1100] *See NATA Market Forecast, supra* note 604, at 3-8.

[1101] *Telephone Trends, supra* note 30, at 26, Table 18. The specific measure used is dial equipment minutes of use (DEMs), which are gauged as calls enter and leave central office switches. In jurisdictional separations studies, DEMs counts are used to estimate the proportion of calls that are interstate in nature and to allocate costs between jurisdictions. *Id.* at 25.

Although the proportion of the average household's total telephone bill represented by local services has risen during the 1980s, the increase has been relatively moderate, particularly since the AT&T divestiture.[1104] In 1980, "basic local service," defined as the monthly service charges for unlimited local service, taxes and subscriber line charges, comprised 29.4 percent of total monthly expenditures for "all telephone service," which included basic local service as well as "toll and other." In 1984, the proportion was 33.8 percent, and in 1989, the proportion was 34.5 percent.[1105] During this time, penetration levels have also risen, even among groups for which penetration is lowest.

Other types of local calling plans, besides unlimited, "flat rate" services now are widely available. In most states,[1106] local measured service (LMS) presents an attractive alternative for many telephone subscribers. Inexpensive "budget plans" are also available in many states. Indeed, in analyzing universal service performance, it is probably more important to focus, not on the average costs of providing unlimited local service, but on what it costs consumers to have some basic or budget type of service. When these types of services become the benchmarks for comparison, the average local rates are much lower than for unlimited calling.[1107]

[1102] *See* "FCC Releases Report on Long Distance Market," FCC News Release No. 12291, at 1 (Mar. 22, 1991).

[1103] *See NATA Market Forecast, supra* note 604, at 6-7.

[1104] *Telephone Trends, supra* note 30, at 14, Table 10.

[1105] *See id.* at 14, Table 11. "Basic local service" is defined in this instance as the monthly service charges for unlimited local service, taxes, and subscriber line charges. "All services" include basic local service as well as "toll and other." The FCC defines the latter as primarily toll services, but also includes charges for such items as equipment, additional access lines, connection, touchtone, call waiting, 900 service, and directory listings. *Id.*

[1106] In 47 of the 48 states in which the BOCs operate, LMS plans are provided to businesses, residences, or both. *See* Bellcore, *Exchange Service Telephone Rates* (1991).

[1107] According to the FCC, the average rate for unlimited local calling in October 1986 was $12.58, and decreased to $12.40 in October 1990. *See Telephone Trends, supra* note 30, at 10, Table 7. In contrast, the average "lowest generally available monthly rate" in October 1986 was $5.96, and decreased to $5.66 in October 1990. *See id.* Thus, this rate was less than half of the average rate for unlimited local calling for the same time.

However, residential ratepayers also generally must pay taxes, charges for emergency 911 service, and state and federal subscriber line charges. For unlimited local calling, these additional charges increased on average from $3.55 in October 1986 to $5.38 in October 1990. *See id.* For the lowest generally available service plans, these charges increased from $3.50 in October 1986 to $4.69 in October 1990. *See id.* Thus, the total package for unlimited local calling was, on average, $16.13 in 1986 and $17.78 (continued...)

Moreover, the FCC and the states have established, and the states are implementing, two low-income assistance programs. States began receiving FCC approval for "Lifeline Assistance" programs in 1985, and the inaugural "Link-Up America" programs began two years later.[1108] The impetus for the latter program was a joint consumer-industry research study conducted by the Consumer Federation of America, the American Association of Retired Persons, and AT&T in 1986.[1109] The study's survey of 3,300 consumers found, among other things, that the inability to pay "front end" costs of getting telephone service, such as installation, constituted the primary reason why households were without phones. In turn, the survey identified unpaid bills and the accompanying disconnection for non-payment as the major cause of drop-offs from the public switched network.[1110]

These targeted assistance programs were designed to help offset the effects on low income local ratepayers of FCC rate restructuring in the mid-1980s. Currently one or both of these programs operate in 48 states, the District of Columbia, and Puerto Rico. From January 1990 through June 1990, Link-Up America had provided assistance to more than 256,000 subscribers nationwide at the cost of $5.5 million in reimbursements to LECs for connection assistance and deferred payments. For the same time period, Lifeline extended help to 2.2 million subscribers at a cost of $29.3 million in payments to LECs for end user subscriber line charge waivers.[1111] Although many other factors apply, the introduction of these programs has undoubtedly contributed to the steady improvement in penetration levels by enhancing the ability of low income Americans to subscribe to telephone service.

[1107] (...continued from preceeding page)
in 1990 (2.5 percent annual growth rate vs. 5.2 percent for CPI for all items), while the corresponding figures from the lowest generally available service plans were $8.84 and $10.35 respectively.

[1108] Lifeline Assistance provides financial assistance to low income subscribers, as defined using a "means" test, with respect to their monthly telephone payments. It includes a waiver of the federal subscriber line charge, plus a reduction of at least a comparable amount in local charges of some type. Link Up America provides connection assistance so that low income subscribers can defray installation charges. The FCC must approve each state's basic program, but the states have considerable flexibility in designing the means tests and the benefits to be conferred. *See id.* at 40-41.

[1109] CFA/AARP/AT&T, *Joint Telecommunications Project* (Feb. 1987).

[1110] *Id.* at 3.

[1111] *See* Federal-State Joint Board Staff Monitoring Report, CC Docket No. 87-339, at Tables 2.2 and 2.3 (July 1991).

c. Discussion

Progress toward reaching the traditional universal service goal has been steady in the last ten years, even with such major changes as divestiture, the rapid growth of competition in interstate services and CPE, and the restructured pricing of interstate services. Indeed, it is with some justification that several parties argue that the traditional goal of universal service has been achieved. Both competition and regulatory reforms have delivered on their promises of increasing the efficiency and value of our telecommunications networks. However, more work remains to be done. As we discuss in the next subsection, the universal service concept should be expanded, and the mechanisms used to achieve the new goal must allow for the realities of a competitive market. Importantly, these policies should be a means of ensuring that telecommunications is a technology of freedom, prosperity, and empowerment for *all* Americans, including those with lower incomes, those with disabilities, and those living in rural areas.

IV. COMMUNICATIONS IN THE INFORMATION AGE: ADVANCED USA

In Chapter 6, we discussed the general policy benefits of increased local exchange competition. We believe that these benefits extend directly to universal service issues as well. Unrestricted entry and competition will motivate local service providers to lower their costs and to price their services consistent with those costs. To a large degree, this could eliminate the need for the elaborate and inefficient private system of cross-subsidies that has been imposed on a variety of local exchange services to keep rates for basic residential services below the possibly inefficient costs incurred by LECs with franchised monopolies.

We recognize, however, that limited targeted subsidies may continue to be needed for high-cost areas of the country and for Americans, such as those with disabilities or low incomes, who cannot otherwise obtain telecommunications services. Any such subsidies should be narrowly focused and should not be used simply to promote one or more advanced services. We are confident that competition, in combination with a limited amount of such targeted assistance, will outperform today's reliance on unchallenged monopoly and massive, broad-gauge cross-subsidies.

A. ADVANCED UNIVERSAL SERVICES ACCESS: ADVANCED TELECOMMUNICATIONS FOR ALL AMERICANS.

1. The Record

Many commenters recommend the inclusion of a wide variety of services, functional capabilities, and technologies in a redefined "universal service" concept.[1112] The Videotex Industry Association, for example, calls for "screen and voice-based interactive services," while CIRI advocates adoption of a national policy for voice and data services.[1113] Others suggest that the "universal service" concept should include directory assistance, emergency services, services for the disabled and non-English speakers, and toll services for rural communities.[1114] Commenters also support the inclusion of touchtone, gateways, access to advanced services with user-friendly interfaces, and user identification addresses.[1115] Technologies frequently mentioned in connection with universal service goals include fiber optic broadband networks, direct broadcast satellite systems, digital stored program control switching, SS7, 800 databases, and ISDN protocols and interfaces.[1116]

Several commenters call for restraint in expanding the services offered as part of "universal service." For example, ADAPSO cautions that uncertain demand may not justify broad deployment of such services.[1117] Moreover, CCTU describes many advanced offerings, such as the eight applications identified by the Intelligent Network Task Force study,[1118] as non-essential.[1119] Access Plus Communications argues that too broad a definition of universal service would have to be subsidized by all ratepayers and thus would be similar to socialized phone service.[1120] CompuServe opposes expanding the definition of universal service to include presently unregulated services.[1121]

[1112] *See generally* Comments of D.C. PSC at 2; Comments of SNET at 44; Comments of NYNEX Corp. at 103-107; *ETI Study, supra* note 550, at 42.

[1113] *See* Comments of VIA at 10; Comments of CIRI at 9.

[1114] *See* Comments of Direct Dialogue Council at 1; Comments of the State of Minnesota at 12; Comments of REA at 12-13; Comments of Cincinnati Bell Telephone Co. at 12.

[1115] *See* Comments of CIRI at 10; Comments of Direct Dialogue Council at 1; Comments of the State of Minnesota at 12; Comments of USTA at 3-4; Comments of BellSouth Corp., App. H at 16-24; Comments of REA at 12; Comments of Cincinnati Bell Telephone Co. at 12; Comments of TDS at 53; Comments of Pacific Telecom, Inc. at 5; Comments of KPMG Peat Marwick at 3; Comments of SNET at 44.

[1116] *See* Comments of CPB at 18-20; Comments of REA at 12; Comments of SBA at 27.

[1117] Comments of ADAPSO at 12.

[1118] *See* Notice, 55 Fed. Reg. at 816, para. 139. These functions include: (1) a transparent gateway to databases and other information services provided by a variety of sources; (2) network protocol conversion; (3) assured privacy for network communications and transactions; (4) simultaneous voice and data services; (5) store-and-forward services such as voice mail, some forms of videotex and (continued...)

REA states that it currently defines rural basic (universal) service as one party service, digital stored program control switching, flat rate local service, worldwide toll access, extended area service (EAS), directory assistance (411), emergency assistance (911), and WATS (800 and 900).[1122] However, REA also opposes the establishment of a detailed definition of universal service in laws or regulation because it could quickly become outdated or otherwise inappropriate.[1123] A case in point, REA notes, is the rural universal service definition that it employed in 1949: a maximum of eight parties, automatic dial switches, automatic selective ringing, 24 hour service, and area coverage.[1124]

REA recommends a different approach. Instead of listing services, it suggests several "universal service component guidelines":[1125]

- Equal access to all subscribers for all providers.
- Nondiscriminatory transport of all services to all providers.
- Access by all subscribers to all health, safety, and emergency services included in the basic monthly charges.
- Access by all local subscribers to all local exchange services.
- Access by subscribers to all network services.

[1118] (...continued from preceeding page)
audiotex, and advanced 976 services; (6) transmission and routing for home-oriented services such as home security; (7) provision for network access by disabled persons and non-English speakers; and (8) as technology advances, services such as automatic language translation.

[1119] Comments of CCTU at 24.

[1120] Comments of APC at 18.

[1121] Comments of CompuServe Inc. at 40; Reply Comments of CompuServe Inc. at 2.

[1122] Comments of REA at 12.

[1123] *Id.*

[1124] *Id.*

[1125] *Id.* at 13.

Similarly, the State of Minnesota asserts that the definition should be flexible and adaptive in order to meet the ever-changing technological and social landscape.[1126]

2. Discussion

In examining the "redefinition" issue, we are sensitive to the fact that groups within the U.S. population and portions of the country even today do not have traditional "basic telephone service." For example, a study in 1990 stated that multiparty lines represented about 2.1 percent[1127] of all residential lines nationwide.[1128] An initial priority must be to provide the opportunity to receive a basic level of service for users in these cases.

However, to meet this need, while providing all Americans with greater opportunities to use advanced telecommunications in the short term, regulators should in the immediate future take moderate steps to redefine the basic service package routinely offered as the minimum necessary to meet the Universal Service goal. In the Notice, we described one current, reasonable definition of this "basic telephone package" to be one-party, voice-grade service with rotary dialing, the ability to receive and place calls, and access to and direct dialing of local and toll calls.[1129] We believe that access to emergency services such as 911 services, equal access to IXCs, and opportunities for the hearing impaired (such as TDD in the short term) should be generally available. As we have seen, REA describes the basic package of telephone service similarly for its purposes.

As a general matter, one rule that regulators should use for determining the services to be included in a "basic package" would be to incorporate all regulated services[1130] that can be provided at, or close to, zero additional cost. Touchtone service is an example. On modern switches, touchtone dialing costs no more to provide than rotary dialing, and it permits users to access advanced network features and information services. Thus, regulators and LECs alike should consider touchtone dialing, rather than rotary, to be part of this basic service package. As such, we recommend that for those subscribers served by switches capable of providing touchtone service (the vast majority of U.S. subscribers), touchtone be incorporated in basic local exchange service, and that separate charges for touchtone be eliminated.[1131] In the FCC's hearing on "Networks of the Future" on May 1, 1991, the Chairman of the California PUC described California's decision to include touchtone in basic residential service. He noted that although this step was costly in a regulatory ratemaking sense (because revenues from surcharges for touchtone had subsidized rates for other services), California is relying on the declining cost characteristics of the telecommunications industry to maintain rates at an overall low level.[1132] Because of the ubiquity and usefulness of touchtone, this modest redefinition is long overdue and merely recognizes technical and service advances that already have occurred.

[1126] Comments of the State of Minnesota at 12.

[1127] *USTA: 1990 Statistics of the Local Exchange Carriers, For the Year 1989* at 11 (Nov. 1990).

[1128] *See* Hudson and Parker, *Information gaps in rural America: Telecommunications policies for rural development*, 15 Telecommunications Pol. 193 (1990).

[1129] *See* Notice, 55 Fed. Reg. at 816, para. 138.

[1130] By "regulated services" we refer to those telecommunications services subject to regulation under Title II of the Communications Act, whether the FCC actively regulates, or forbears from regulation in particular cases. This is the class of services the FCC refers to as "basic" services, as opposed to "enhanced" services. As we noted *supra* note 1046, it is not our intent in recommending Advanced USA that the FCC expand the scope of its regulation to non-Title II services.

Services with costs significantly greater than zero[1133] should be available on an optional basis, with prices set at or near cost. Although we recognize that actual costs are difficult to determine, and that such services may properly be required to make some contribution to common costs, we also believe that it is important that such services not be priced "vertically"—*i.e.*, substantially above cost. Such pricing will generally be neither efficient (because it sends the wrong price signals to providers and consumers) nor equitable (because it makes these services less affordable, particularly for low-income users). Increased availability of services in an optional, cost-based way will permit better use of advanced telecommunications, even in the relatively short term.

A broader vision is needed for the long term, however, as additional features and capabilities are incorporated into the local basic networks, and are available from unregulated service providers. We believe the pro-competitive, deregulatory policies endorsed in Chapter 6 will create the opportunities and incentives for the rapid, efficient development of an advanced telecommunications infrastructure in this nation that will well serve the vast majority of our citizens. It is also in the national interest to have as a national policy goal the participation of all our citizens in this advanced infrastructure. Thus, instead of seeking only to provide a specified "package" of services, in the long term, the FCC, the states, and the telecommunications industry should seek to make the nation's telecommunications infrastructure transparent, in terms of providing users access to such capabilities, throughout the nation.

[1131] *See* Notice, 55 Fed. Reg. at 817, para. 144.

[1132] Telecommunications Reports, May 6, 1991, at 39.

[1133] It is difficult, of course, to define "significantly" but, for example, the marginal costs of some capabilities, such as ordering and billing, may be below the marginal costs of breaking them out as optional services.

We call this goal Advanced Universal Service Access (Advanced USA). Such national transparency can best be achieved by introducing pro-competitive policies throughout the country, coupled with the types of interconnection, pricing, and standards policies we described in Chapter 6. Those policies should be sufficiently flexible to support Advanced USA. Thus, in addition to the "basic service package" described above, a residential user ultimately should have access, at competitive prices that reflect costs, to the features available to other U.S. residential users.[1134] For successful implementation, Advanced USA should rely, not on lists of government-mandated services, but on comprehensive reform to eliminate the regulatory barriers to entry and inefficient pricing practices that now limit the deployment of new services.

The features or functionalities that are elements of Advanced USA should be defined in a technologically-neutral way. Given the ever-changing mix of technologies in networks, any one of several technologies could be used to provide a particular capability or service at any one moment.[1135] Moreover, as technologies evolve, the choice among them often expands. Telecommunications providers seeking to meet Advanced USA goals should be free to implement different underlying technologies in response to changing cost-performance factors and new developments, rather than be constrained by regulatory fiat that would mandate the use of specific technologies.[1136]

An important component of Advanced USA is the recognition that services or capabilities need not be available only through a traditional common carrier, such as a LEC or IXC. Indeed, many capabilities of use to residential customers, such as speed dialing, call-hold functions, and voice-message services are more widely available through CPE than through any provider's network. Similarly, unregulated alternative service providers may offer some capabilities before they are available from traditional carriers. In some such cases, however, capabilities may be "available" in a technical sense, but offered in a way that, for the ordinary citizen, is not "user friendly" or affordable. Thus, in evaluating progress toward the goal of Advanced USA, as in compiling the profile discussed above, policymakers should consider the availability of features provided through CPE and unregulated alternative providers, but keep in mind these concerns about the ability of the ordinary subscriber to make practical use of such features.

[1134] Advanced USA does not mean that all advanced services have to be provided in all parts of the country at the same time. Such a requirement would be neither technically feasible nor economically desirable. Moreover, some features that are initially offered to consumers may not receive widespread acceptance in the marketplace, as it may be difficult to gauge the needs of consumers or fully anticipate the development of alternative approaches or technologies that provide the same or improved functionality more successfully. Thus, Advanced USA would not require that as soon as any service is offered in one region of the country it would automatically have to be offered in all other regions. Rather, a more measured, evolutionary approach to making advanced features available is contemplated.

[1135] For example, touchtone and equal access to long distance carriers are provided using both analog and digital switches.

[1136] New developments may include technical advances or new demand that allow providers to take advantage of scope economies offered by particular plant.

B. Universality Issues: Availability and Affordability.

We have discussed our commitment to the goal of Advanced USA. Advanced telecommunications services should be available to all Americans on a reasonably equal basis. In this subsection, we discuss how this "extended" goal can be implemented in an affordable way through the competitive approach we describe in Chapter 6.

We believe that telecommunications competition will improve service quality and lower prices for most users, and could attract use by some who are not now served. While competition will drive prices to costs, even more importantly, it will force firms to operate more efficiently, lowering their costs as well. Moreover, open entry policies could spur present monopoly providers or new entrants to serve currently unserved areas,[1137] particularly in light of developing radio, satellite, and fiber technologies.[1138]

OTA recently proposed the development of "Rural Area Networks" (RANs) that would "link up as many users within a community as possible—including among them businesses, educational institutions, health providers, and local government offices."[1139] According to OTA, RANs would take advantage of the unbundling of network capabilities stimulated by the FCC, and the new technologies and efficiencies now enjoyed by businesses that use private networks.[1140] This proposal could be seen as one form of local exchange competition, because presumably RANs are not equivalent to the existing networks of rural LECs. As OTA recommends, policymakers should encourage technology deployment strategies that will work through—not against—market forces.[1141] OTA apparently views even its own RAN proposal as potentially posing a regulatory "problem"—that is, a "large and coordinated group of users could establish its own network and bypass the public network."[1142] To the contrary, we view local exchange competition, even in rural areas, as an opportunity that regulators should embrace and promote, while recognizing that special concerns will need to be taken into consideration.[1143]

[1137] In June 1991, Oregon adopted legislation to expand telephone service to unserved rural areas. *See* 1991 Or. Laws 307.

[1138] In order to permit the many potential benefits of these emerging technologies to be fully realized, however, current spectrum management policy must be made more efficient and more open. *See Spectrum Report, supra* note 13, at 1-12. *See also Broadcasting*, May 6, 1991, at 51-52.

[1139] *OTA Rural Report, supra* note 1068, at 9.

[1140] *Id.* at 8-9.

We recognize that there may be market segments (in terms of types of services or geographic areas) in which competition develops slowly or, at least in the short term, not at all.[1144] However, this, by itself, is not a reason to abandon our recommended policies of removing regulatory entry barriers, mandating interconnection, permitting pricing flexibility, and targeting subsidies. If entry does not occur, or if it occurs and fails, LECs should remain subject to incentive regulation with respect to those areas or services.[1145]

1. Implications of Cost-based Pricing for Universal Service Objectives

In Chapter 6, we advocated adoption of flexible, cost-based pricing for regulated telecommunications services. Such an approach has many advantages because, if successful, cost-based prices will produce incentives and welfare gains for both service providers and consumers that are similar to those that would prevail in a competitive market. However, it is possible that even such pricing could require measured support mechanisms or subsidies to ensure the availability of affordable telecommunications services to all users in all geographic areas. As we have noted, the existence of network externalities, of whatever size, could militate in favor of setting the price of network access below cost, at least for some targeted portion of subscribers, in order to produce a desired level of subscribership. Some form of subsidy would be needed to make up the resulting revenue deficiency. Additionally, to the extent that rates for specific services in particular areas are now priced below relevant costs (*e.g.*, residential telephone service and services in so-called "high cost areas"),[1146] a move to cost-based pricing could require some increases in those rates.[1147] Thus, some targeted support mechanisms could well remain necessary to ensure that such increases do not adversely affect the goals of providing service to underserved portions of the population.[1148]

[1141] *Id.* at 31.

[1142] *Id.* at 128-129.

[1143] The *OTA Rural Report* expresses concern that the partially competitive post-divestiture climate has diminished traditional subsidies to high-cost areas, and that increased competition could further erode these amounts. *Id.* at 116 n.3. As we discuss below, more equitable and efficient targeted subsidies, coupled with increased opportunities for competitive entry, should replace the economically wasteful current system. Indeed, as OTA recognizes, even the limited competition available now has encouraged alternative providers, such as digital radio carriers, to enter markets with products that can improve rural service. *Id.* at 116.

[1144] *See Panzar, supra* note 809, at 8-9.

[1145] Even where the rigors of competition supplant the need for regulation in a given market, we would expect that monitoring of the performance of that market could be periodically conducted by the appropriate governmental body.

[1146] As we have noted, rates in high cost areas are now commonly subsidized through a system of rate averaging. In certain circumstances, increased competition will tend to place pressure on such a system. That being said, we recognize that not all forms of rate averaging are inefficient or unsustainable in the face of competitive entry. Although, in theory, the rates to each subscriber should reflect the marginal costs of serving that subscriber, in practice, establishing a separate price for each customer is too costly. Thus, some degree of rate averaging is necessary. *See Kahn and Shew, supra* note 918, at 232-233. To the extent that such averaging is driven by economic factors, it will not be as vulnerable to competitive entry as rate averaging schemes that reflect other factors, such as promoting social goals.

Both factors may be at work in the geographic averaging of interstate long-distance rates. AT&T has traditionally charged the same for calls of the same distance regardless of the points of origination or termination of the calls. While the FCC has not formally required such averaging, it has expressed a strong preference for this type of rate structure and indicated that any proposal by AT&T to abandon this approach would be subject to a full investigation. *See AT&T Price Cap Order*, 4 FCC Rcd at 3132-3134.

NTIA supports the FCC's position on this issue. While this appears to be an example of rate averaging for social policy reasons, it has thus far not proved to be unsustainable in the face of the significant growth in competition in the interstate market. Indeed, AT&T's two largest competitors, MCI and Sprint—as well as many of its smaller competitors—also employ geographically averaged rate structures, despite the fact they are under no regulatory obligation to do so. If geographically-averaged rates were extremely uneconomic, one would expect more aggressive attempts by these competitors to take advantage of opportunities to undercut AT&T's prices on low-cost routes. Moreover, we believe that the FCC should continue its rate integration proceedings for Alaska and Hawaii.

[1147] We stress again that it is likely that competition will force down the costs and prices associated with a LEC's operation. Thus, prices reflecting actual costs in a competitive market will not necessarily be higher than subsidized prices in a monopolized market, given the inefficiencies and higher costs frequently associated with the behavior of firms that do not face competition. Nevertheless, we acknowledge the possibility that the prices of some currently subsidized services could increase in a more competitive local exchange market setting.

[1148] Studies indicate that, while bringing telecommunications service rates in line with marginal costs would produce large welfare gains in the aggregate, the lowest income groups in the U.S. could suffer a decline in welfare. *See Kahn and Shew, supra* note 918, at 253-54 (citing Perl, *Welfare Gains from Cost-Based Telephone Service* (June 19, 1986)). NTIA believes that it is entirely appropriate, as a matter of policy, to develop a subsidy mechanism to ameliorate this impact. It is equally important, however, that the desired subsidies are generated and distributed in a way that causes the least possible loss in aggregate welfare.

2. Cost Support Mechanism

As we have discussed, regulators have long allowed telephone company rates to support a system of private, but regulatorily-sanctioned, subsidies flowing from urban to rural areas, and from business to residential users.[1149] This system of private subsidies is so broad and applies so generally that its impact in promoting service to those least able to afford a telephone—low income households—has been substantially diluted.[1150]

Under the present system, these private subsidies have been broadly distributed with little attention paid either to their actual effectiveness in serving the goal of attracting non-subscribing, low income households onto the networks, or to their distorting effects on efficiency in the operation and use of the public networks. The jurisdictional separations and settlements process have become blunt instruments for implementing social objectives through cost and revenue allocation and assignment.

The FCC and the states in recent years have acted to make the support programs more economically efficient, explicit, and targeted. The Universal Service Fund (USF) is being phased in during an eight-year period that began in 1986. Its primary goal is to ensure that telephone rates remain affordable for all Americans by targeting assistance to those LECs whose non-traffic sensitive (NTS) costs, the largest cost component of telephone service, are substantially above average.[1151] IXCs support this fund through the access charges they pay LECs. Formulas that consider LEC size and the difference between NTS costs per loop for the LEC and the industry average determine participation in the fund. In addition, the Lifeline and Link-Up America assistance programs began during the same period.

[1149] For a concise discussion of past and present policies of subsidizing telecommunications services and users, see *Domestic Study, supra* note 775, at 144-156.

[1150] When subsidies are broadly distributed, their costs can quickly become prohibitive. As a result, the amount of subsidy given to each person has to be fairly limited if the subsidy approach is to be at all sustainable. This has tended to be the result with subsidies for basic local service, which typically have been available to all residential subscribers from the very wealthy to the very needy. By contrast, the per-person amount of subsidy possible with a targeted approach—such as the Lifeline or Link-Up programs—can be substantial, while the total costs of the program are relatively small, especially compared to those of the current system. Thus, targeted subsidies can be both more effective in achieving universal service goals and more efficient in economic terms than the current broad-based subsidy programs.

[1151] *See* General Accounting Office, U.S. Congress, *Telephone Communications: Issues Affecting Rural Telephone Service*, GAO/RCED-87-74, at 24 (Mar. 1987).

Despite these advances, the current programs have shortcomings. Although the USF assists high-cost LECs, it does not create strong incentives for them to operate more efficiently. REA's loan programs assist rural LECs whether or not their customers have low incomes, or their costs of providing service are exceptionally high.[1152] While these programs have had salutary effects in keeping rates low in certain areas of the country, they may not deliver as "big a bang for the buck" in promoting universal service goals as programs (such as the Lifeline and Link-Up America programs) that target the appropriate customers (rather than providers) with the explicit assistance that is needed and warranted.

Traditional hidden subsidies are particularly difficult to sustain in a competitive environment because they create "false" pricing signals that cause non-optimal investment expenditures.[1153] In the extreme case, continued attempts to fund such subsidies through above-cost pricing in the face of competition could lead some subscribers (those with competitive alternatives) to drop off the public network, causing rates to rise for the remaining users, leading to more drop-offs. Such an effect is a flaw of the current regulatory system, which is not designed to capture the benefits of competition for local users.

States are already considering different ways of reconciling existing subsidy structures with competition. Massachusetts and California are considering whether to require competitors of LECs to contribute funds for universal service purposes as part of arrangements for interconnection to LEC facilities.[1154] We encourage such efforts and urge the states to eliminate wasteful, hidden subsidies from telephone company rate structures.

In a series of landmark decisions, the New York PSC has conditioned competition by alternative providers with LECs on establishment of a fund to meet universal service needs.[1155] In its 1989 *Interconnection Order*, the PSC emphasized that this action was

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[1152] *See OTA Rural Report*, *supra* note 1068, at 69 n.51 (telephone companies that borrow from REA have relatively low costs compared to large companies).

[1153] *See supra* notes 1035-1036 and accompanying text.

[1154] *See* Teleport Communications Group News Release at 2 (Feb. 20, 1991).

[1155] Overruling an Administrative Law Judge's finding that Teleport's petition for collocation of its facilities at New York Telephone's central office reflected an "artificial perspective" on competition, the New York PSC determined that "[a]llowing liberal interconnections with the local exchange network generally fosters competition and will likely provide more effective and efficient carrier access service."

(continued...)

designed to foster competition while minimizing unreasonable or extraordinary adverse impacts on other ratepayers. To do so, it must be evenhanded and must consider mitigating demonstrated losses of existing contribution that would result from this action.[1156]

In January 1991, New York Telephone filed an "actual collocation" tariff that included a proposed "Universal Service" rate element.[1157] Under this proposal, "interconnectors" with certain of the LEC's private line service components would pay an access charge that is designed to offset the loss of contribution resulting from these interconnection arrangements.[1158] In May 1991, the New York PSC approved the proposed "Universal Service" rate element, the first of its kind in the country.[1159]

Commentators have suggested numerous other ways to reconcile the availability and affordability goals of the traditional universal service concept with changes in current residential prices, including the introduction of competitive pricing. For example, one economist suggests that, because the price elasticity of demand for telephone access (*i.e.*, basic telephone service) is very low, price increases would not greatly reduce the number of subscribers. He further contends that even "this small negative effect" can largely be offset if LECs make available a "budget plan" in the form of inexpensive local measured service to those who would drop off the network if only expensive flat-rate access were available.[1160] Others have proposed that subsidies be derived from general tax reve-

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1155 (...continued from preceeding page)

New York Interconnection Order, 103 PUR4th at 14.

In addition to the ability of private line competitors to interconnect on a "virtual collocation" (*i.e.*, comparably efficient interconnection) basis, the New York PSC granted New York Telephone increased pricing flexibility and imposed several conditions on the entrants. Among the conditions were the requirement that Teleport allow similar access to its facilities by all interested carriers, including New York Telephone. *Id.* The New York PSC did not grant Teleport's request for interconnection to the LEC's switched access services because unbundling of switched access service elements was viewed as infeasible. However, the agency said that, after removal of the restriction on New York Telephone switched access pricing flexibility contained in the AT&T Consent Decree, "this market will likely become competitive." *Id.* at 15.

[1156] *Id.* at 26-27.

[1157] *See* Letter from Cornelia McDougald, New York Telephone Company, to John J. Kelliher, Secretary, New York PSC (Jan. 10, 1991) (with attachments).

[1158] *Id.*, Tab A at 3-5.

[1159] New York PSC, *Competition Proceeding Order* (adopted May 8, 1991).

[1160] *See Wenders, supra* note 985, at 190-91.

nues.[1161] Another possibility for sources of subsidies would be through surcharges or fees on all business and residential subscribers in a state.

3. Discussion

NTIA believes that Advanced USA should be based on the low costs and prices that competition in the provision of local services will provide. We do not advocate that any particular set of advanced services be supported through generalized subsidies. Nevertheless, we recognize that in certain circumstances, regulators may conclude that some level of subsidy is necessary for universal service purposes. We strongly recommend, however, that any such subsidies be targeted to those subscribers least likely to be able to afford telecommunications services, in the absence of some form of assistance. Such subscribers would be those in lower income groups, those with disabilities that prevent them from using conventional telecommunications services (such as the hearing impaired), and some located in remote areas of the country. We anticipate that any such subsidies will be much more limited than the substantial, wasteful, and hidden cross-subsidies of today.

Possibly the most crucial aspect of ensuring the affordability of local service will be a commitment by federal and state regulators alike to competition, and the benefits it can bring to users. We wish to stress that competition, while driving prices toward cost, will also have the effect of forcing LECs to lower their costs, thus representing a clear improvement upon monopoly-based regulation that permits costs to become inflated. Moreover, competition could motivate regulators to permit LECs to provide several types of local measured service alternatives with low monthly flat rate charges that could help retain low income subscribers on the network. Thus, one important contribution to Advanced USA by regulators will be a steadfast dedication to allowing both entry and pricing flexibility to occur.

Further, regulators should seek to narrow and target any subsidies found to be necessary. Subsidizing whole classes of subscribers (*e.g.*, all residential subscribers) is unnecessary to further universal service goals. Such broad subsidies are very inefficient and would be unsustainable in a competitive environment. "Universal" subsidies can generally only be paid for by "taxing" the very same subscribers that they are supposed to help, through above-cost pricing for certain services (*e.g.*, long-distance calling or "optional" features).

[1161] *See Back to the Future*, *supra* note 931, at 196-197. *See also Wenders*, *supra* note 985, at 191.

The end result is a byzantine system of elaborate cross subsidization that is arbitrary (in terms of who ultimately is subsidized and who is subsidizing) and market-distorting and, thus, serves neither equity nor efficiency goals.

Ideally, the sources of any needed subsidies should be explicit, so that those who are paying for such subsidies can determine their extent. Although, as noted above, there have been numerous suggestions for the sources of these subsidies, no single source is the "best" in an absolute sense. For example, it has been argued that general tax revenues would be the fairest and most efficient means of funding the subsidies,[1162] although, as Kahn notes, there are "practically no neutral taxes . . . that do not in one way or another distort the functioning of a price system."[1163]

Given the political reality that there are numerous competing uses for general tax revenues, other possibilities should also be considered that could generate monies for such subsidies from telecommunications users. For example, as we note in Chapter 6, to the extent that incentive regulation is in place, sharing mechanisms could fund subsidy programs.[1164] In addition, we see much merit in the New York PSC's work in attempting to support universal service funds through contributions by local access competitors, much as IXCs contribute to the FCC's Universal Service Fund. We believe that this approach, while promising, could be modified to more specifically target the appropriate end users as recipients of such funding.

Another alternative for either a monopoly or competitive environment would be to levy a "universal access" surcharge or fee on all business and residential subscribers. Wenders justifies such an approach as doing "the least damage to economic efficiency because it would fall on the most inelastic service in the telecommunications industry."[1165] More importantly, such an approach would be fair since the subsidies would be borne by the broadest possible spectrum of telecommunications users.

In light of the complexities of these competing concerns, there may not be any single "right" answer to the question of funding whatever support mechanisms are deemed necessary. Rather, we recommend that the FCC and the states move to introduce local exchange competition and evaluate the extent to which any subsidies are needed. If subsidies are found to be necessary, the FCC and the states should apply the criteria we have discussed to develop explicit and targeted sources of subsidy for Advanced USA activities within their respective jurisdictions.

[1162] *See, e.g., Wenders, supra* note 985, at 191; *Back to the Future, supra* note 931, at 196-197.

[1163] 2 *Kahn, supra* note 135, at 130 n.15.

[1164] *See supra* note 916 and accompanying text.

[1165] *Wenders, supra* note 985, at 191.

V. CONCLUSION

Historically, the availability of telephone service in this country has been a national concern and the pursuit of "universal service" has been a long-standing national goal. Americans must renew our commitment to this goal and update it in light of the benefits that today's technologies can bring. Therefore, U.S. telecommunications policy must expand on our goal as we move into an era of universal information services. Much has been accomplished in providing basic voice telephone service to all Americans, although more must be done. The emergence of the world economy has brought with it new requirements for national telecommunications policy. Objectives such as economic development and competitiveness in global markets are becoming as important to the well-being of the U.S. populace as telephone penetration rates. The promised benefits of even better telecommunications technology mean that provision of traditional voice services through government-sanctioned monopolies can no longer suffice as the goal for universal service. Rather, universal access to the myriad services available in the competitive telecommunications marketplace should become the new standard.

The regulatory "summit meetings" that the FCC and the states periodically conduct present an appropriate setting for an initial discussion of transforming the traditions of universal service into the vision of Advanced USA, as we move from the era of centralized, monopoly planning to an era of dynamic competition to benefit all Americans. The changes needed to realize that transformation must occur in a thoughtful, purposeful way as the United States adapts its telecommunications system to the future. The FCC should commence a rulemaking proceeding to explore how Advanced USA can be implemented. We urge the FCC, in consultation with the states, to make this approach a conceptual keystone of its policy framework for an advanced universal information network.

Appendix A

List of Commenters, Filings, Symposium and Field Hearings

INITIAL COMMENTS

Access Plus Communications, Inc.
Ad Hoc Telecommunications Users Comm.
Alascom, Inc.
Alliance For Public Technology
American Legislative Exchange Council
American Library Ass'n
American Mobile Satellite Corp.
American Newspaper Publishers Ass'n
American Petroleum Institute
American Radio Relay League
Ameritech
Arthur Andersen & Co
Associated Public-Safety Communications Officers, Inc.
Association of American Railroads
Association of Data Processing Services Organizations, Inc.
Association of Independent TV Stations, Inc.
Association for Local Telecommunications Services
AT&T
Bell Atlantic
Bellcore, Southern New England Telephone Co., Cincinnati Bell Telephone Co.
BellSouth Corp.
BT Tymnet, Inc.
California Public Utilities Commission
Centel Corp.
Cincinnati Bell Telephone Co.
Citizens for a Sound Economy Foundation
Citizens Utilities Co.
Committee of Corporate Telecommunications Users
Competitive Telecommunications Ass'n
CompuServe Inc.
Computer & Business Equipment Manufacturers Ass'n
Consumer Interest Research Institute
Contel Corp.

INITIAL COMMENTS (Cont.)

Continental Cablevision
Corporation for Public Broadcasting
County of L.A., Internal Services Dept.
Covington, Jere, *et al.*
Cox Enterprises, Inc.
Cybertel Corp.
Digital Equipment Corp.
Direct Dialogue Advisory Council, MN
Direct Dialogue Council, Des Moines, IA
Direct Dialogue Council, Marshall, MN
Direct Dialogue Council #5, Urbandale, IA
District of Columbia Public Service Comm'n
Dordrick, Herbert
Eastman Kodak Co.
Egan, Bruce
Ericsson Corp.
Exchange Carriers Standards Ass'n
Fisher, Francis Dummer
Florida Public Service Comm'n
France Telecom, Inc.
Galvin, Thomas J.
General Communication, Inc.
General Electric Communications & Services
Global Telematics
GPT, Ltd
Graniere, Robert
GTE Service Corp.
Hudson, Heather
Idaho Public Utilities Comm'n
Independent Data Communications Manufacturers Ass'n, Inc.
Independent Telecommunications Network, Inc.
Information Industry Ass'n
International Communications Ass'n/Consumer Federation of America
Jersey City State College
Johns Hopkins Health Center
Kirkwood Community College
KPMG/Peat Marwick
Litel Telecommunications Corp.
Lower Mississippi Delta Development Comm'n
Marcar Management Institute
McCaw Cellular Communications, Inc.
MCI Telecommunications Corp.
Medicine for the 21st Century

INITIAL COMMENTS (Cont.)

MessagePhone, Inc.
Metropolitan Fiber Systems, Inc.
Midlands Consortium
Milano, Joseph
Minnesota Direct Dialogue Council Five
Minnesota Extension Service II
Minnesota Extension Service I
MIT Media Laboratory
National Aeronautics & Space Administration
National Ass'n of Broadcasters
National Ass'n of College Broadcasters
National Ass'n of Public Television Stations & Public Broadcasting Service
National Ass'n of Towns and Townships
National Cable Television Ass'n, Inc.
National Center for Telecommunications and Information Policy/Public Service Satellite Consortium
National Governors Ass'n
National Telephone Cooperative Ass'n/Organization for the Protection and Advancement of Small Telephone Companies
New York City, Energy and Telecommunications Office
New York State Public Service Commission
North American Telecommunications Ass'n
North Dakota Direct Dialogue Eastern Council
Northern Telecom
NYNEX Corp.
Office of Communications, United Church of Christ
OPT in America
Oregon Department of General Services
Organization of State Broadcasting Executives
Pacific Telecom, Inc.
Pacific Telesis Group
Phone Spots, Inc.
Prodigy Services Co.
Radio Reading Service of Western New England, Inc.
Rifkin, Maurice
Rochester Telephone Corp.
Rural Electrification Administration
Saint Joseph's University
Schmidt, Leland
Siemens Corp.
South Carolina Division of Information Resource Management
Southern New England Telephone Co.

INITIAL COMMENTS (Cont.)

Southwestern Bell Corp.
State of Hawaii
State of Minnesota
Swedish Telecom Group
Technology Futures, Inc.
Tele-Communications, Inc.
Telecommunications Industry Ass'n
Telephone and Data Systems, Inc.
Telocator
Town of Bloomsburg, PA
United States Telephone Ass'n
United Telecommunications, Inc.
University of Tennessee
University of Pittsburgh, Department of Information Sciences
University of Pittsburgh Medical Center
US Department of Education
US Small Business Administration
US Small Business Administration, Des Moines, IA
US West
Utilities Telecommunications Council
Verilink Corp.
Videotex Industry Ass'n
Washington Utilities and Transportation Comm'n
West Chester University, Office of Information Services
Yznaga, Mary

REPLY COMMENTS

AccessPlus Communications, Inc.
Ad Hoc Telecommunications Users Comm.
Alascom, Inc.
Alliance for Public Technology
Association for Local Telecommunications Services
Association of Independent Television Stations, Inc.
AT&T
Bellcore, Southern New England Telephone Co. and Cincinnati Bell Telephone Co.
BellSouth Corp.
Citizens for a Sound Economy Foundation
CompuServe Inc.
Corporation for Public Broadcasting
Cybertel Corp.

REPLY COMMENTS (Cont.)

FMR Corp.
France Telecom, Inc.
General Communication, Inc.
GPT, Ltd.
GTE Service Corp.
Hudson, Heather
International Communications Ass'n
Litel Telecommunications Corp.
Magnetic Press
McCaw Cellular Communications, Inc.
MCI Telecommunications Corp.
MessagePhone, Inc.
Metropolitan Fiber Systems, Inc.
National Aeronautics & Space Administration
National Ass'n of Regulatory Utility Comm.
National Ass'n of State Utility Consumer Advocates
National Cable Television Ass'n, Inc.
National Exchange Carrier Ass'n
National Rural Telecom Ass'n
Northern Telecom
NYNEX Corp.
OPT in America
Pacific Telesis Group
Prodigy Services Co.
Southwestern Bell Corp.
State of Alaska
State of Hawaii
Tele-Communications, Inc.
Telephone and Data Systems, Inc.
Teleport Communications Group
United States Telephone Ass'n

SUPPLEMENTAL FILINGS

Comments

International Communications Ass'n

Studies

Davidson, Dibble, and Hom:	*Telecommunications and Rural Economic Development* (Oct. 1990)
DRI/McGraw-Hill:	*The Contribution of Telecommunications Infrastructure to Aggregate and Sectoral Efficiency* (Feb. 1991)
DRI/McGraw-Hill:	*The Contribution of Telecommunications Infrastructure to Aggregate and Sectoral Efficiency* (Nov. 1990)

Letters

Letter from Brian R. Moir, Fisher, Wayland, Cooper and Leader, to William F. Maher, Jr., NTIA (May 3, 1991)

Letter from Christopher W. Savage, Bell Atlantic to Brian R. Moir, Fisher, Wayland, Cooper and Leader (Feb. 19, 1991)

Letter from Brian R. Moir, Fisher, Wayland, Cooper and Leader, to William F. Maher, Jr., NTIA (Feb. 6, 1991)

Letter from Christopher W. Savage, Bell Atlantic, to William F. Maher, Jr., NTIA (Jan. 11, 1991)

Symposium and Field Hearings

NTIA, in conjunction with the Annenberg Washington Program of Northwestern University, conducted a symposium on telecommunications and rural development. The conference assembled leading experts from the telecommunications industry, government, the business community, and academia. Subjects explored at the conference included: the vital importance of telecommunications for rural business and the delivery of social services; new telecommunications technologies and their potential for rural use; and, how the federal and state governments can promote rural development through the innovative use of telecommunications.

- Washington, D.C.: March 2, 1990

In addition, NTIA conducted, in conjunction with the Alliance for Public Technology, four field hearings on infrastructure and rural issues:

- Albuquerque, New Mexico: March 29, 1990
- Newark, New Jersey: May 11, 1990
- San Diego, California: June 4, 1990
- Detroit, Michigan: June 26, 1990

Appendix B

Alphabetical List of Commenter Acronyms and Abbreviations

AAR	Association of American Railroads
ADAPSO	Association of Data Processing Services Organizations, Inc.
AHTUC	Ad Hoc Telecommunications Users Comm.
ALA	American Library Association
ALTS	Association for Local Telecommunications Services
AMSC	American Mobile Satellite Corp.
ANPA	American Newspaper Publishers Association
APC	Access Plus Communications, Inc.
APCO	Associated Public-Safety Communications
API	American Petroleum Institute
APT	Alliance for Public Technology
ARRL	American Radio Relay League
BELLCORE	Bellcore, Southern New England Telephone, Cincinnati Bell
California	People of the State of California and the California Public Utility Commission
CBEMA	Computer & Business Equipment Manufacturers Association
CCTU	Committee of Corporate Telecommunications Users
CIRI	Consumer Interest Research Institute
CITIZENS	Citizens for a Sound Economy Foundation
COMPTEL	Competitive Telecommunications Association
CPB	Corporation for Public Broadcasting
D.C.PSC	District of Columbia Public Service Commission
DEC	Digital Equipment Corporation
ECSA	Exchange Carriers Standards Association
Enertel	New York City Energy & Telecommunications Office
GECS	General Electric Communications & Services
ICA/CFA	International Communications Association/Consumer Federation of America
IDAHO PUC	Idaho Public Utilities Commission
IDCMA	Independent Data Communications Manufacturers Association, Inc.
IIA	Information Industry Association
INTV	Association of Independent TV Stations, Inc.

ITN	Independent Telecommunications Network
LITEL	Litel Telecommunications Corporation
LMDDC	Lower Mississippi Delta Development Commission
McCaw	McCaw Cellular Communications
MFS	Metropolitan Fiber Systems, Inc.
NASA	National Aeronautics and Space Administration
NAB	National Association of Broadcasters
NAPTS/PBS	National Association of Public Television Stations and the Public Broadcasting Service
NASUCA	National Association of State Utility Consumer Advocates
NATA	North American Telecommunications Association
NCTA	National Cable Television Association
NCTIP	National Center for Telecommunications and Information Policy/Public Service Satellite Consortium
New York PSC	New York State Public Service Commission
NGA	National Governors Association
NTCA/OPASTCO	National Telephone Cooperative
Oregon DGS	Oregon Department of General Services
Pactel	Pacific Telesis Group
REA	Rural Electrification Administration
SBA	U.S. Small Business Administration, Des Moines, IA
SNET	Southern New England Telephone Co.
South Carolina DIRM	South Carolina Division of Information Resource Management
TCI	Tele-Communications, Inc.
TDS	Telephone and Data Systems, Inc.
TFI	Technology Futures, Inc.
TIA	Telecommunications Industry Association
UCC	Office of Communications, United Church of Christ
USTA	United States Telephone Association
UTC	Utilities Telecommunications Council
VIA	Videotex Industry Association
Washington UTC	Washington Utilities and Transportation Commission

Appendix C

DRI Study: A Review

Office of Policy Analysis and Development
Staff Paper[1166]
By
Mark Bykowsky, William Maher, and Timothy Sloan[1167]

I. INTRODUCTION

Of the many filings that NTIA received in response its Notice of Inquiry, only one, submitted by DRI/McGraw-Hill (DRI), attempts to quantify the gains in the U.S. economy's productivity that are attributable to improvements in telecommunications infrastructure.[1168] One of the purposes of DRI's study is "to assist federal and state policymakers in assessing the importance of a modern telecommunications infrastructure to the overall operation of the [U.S.] economy."[1169] Because such an analysis would have a substantial bearing on the issues raised in the Notice, this appendix examines DRI's study in some detail.

DRI's principal conclusion is that "increased investment in telecommunications infrastructure during the period 1963 to 1982 significantly contributed to increased productive efficiency and overall economic growth."[1170] This assessment flows from two findings. First, DRI estimates that efficiency gains in the production of telecommunications services and increased consumption of such services from 1963 to 1982 saved the

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[1166] The views expressed herein are those of the authors, and do not necessarily reflect the views of the National Telecommunications and Information Administration.

[1167] The authors are grateful to Leland Johnson, Alfred Lee, Bridger Mitchell, and William Shew for helpful comments.

[1168] Data Resources/McGraw-Hill, *The Contribution of Telecommunications Infrastructure to Aggregate and Sectoral Efficiency* i, vii, 15 (Feb. 1991) (*DRI Study*) (submitted on behalf of Ameritech, Bell Atlantic, BellSouth, Cincinnati Bell, the GTE telephone companies, NYNEX, Pacific Bell, Southern New England Telephone, Southwestern Bell, United Telephone, and US West). This study updates and expands in certain respects a paper that DRI submitted to NTIA in November 1990.

[1169] *Id.* at 1.

[1170] *Id.* at ii.

U.S. economy $81.3 billion in labor and capital resources in 1982.[1171] Second, based upon a statistical analysis of telecommunications investment and economic output data from 1958 to 1988, DRI concludes that "increased telecommunications investment and usage causes (in a statistical sense, is a good predictor of) economic growth in later years."[1172] In DRI's view, these findings "provide[ ] a solid basis for national telecommunications policies designed to stimulate investment in U.S. telecommunications infrastructure."[1173]

The DRI study is an ambitious attempt to assist policymakers in designing effective telecommunications infrastructure policy, and has sparked some controversy in the record compiled for this report.[1174] Nevertheless, even commenters that criticize aspects of DRI's work agree with the "general proposition that telecommunications growth has engendered positive benefits for the U.S. economy."[1175] However, as discussed below, several methodological issues limit the study's usefulness in analyzing infrastructure policy. In examining these issues we encourage policy analysts to continue to develop and improve upon the models and methods pioneered by DRI.

[1171] *See id.* (resource savings measured in 1990 dollars). As DRI points out, the labor and capital resources saved could used to fuel growth in other sectors of the economy.

[1172] *Id.* at viii. *See generally id.* at F.1-F.7.

[1173] *Id.* at F.6. DRI's first finding implies that gains in the production and consumption of telecommunications have enabled the telecommunications industry and telecommunications users to produce the same levels of output using fewer resource inputs. In other words, such gains have fostered an increase in the nation's productivity. Productivity growth, in turn, is the single most important determinant of a nation's standard of living, the consistent improvement of which is a fundamental concern of sound economic and social policy.

DRI's second finding suggests a causal relationship between telecommunications investment and economic growth (measured in terms of GNP or total output). However, output growth does not necessarily imply an increase in either productivity or living standards.

[1174] For criticisms of DRI's work, see Roddy, *A Summary of the Debate over Statistical Models Used by the Regional Bell Operating Companies in Support of Accelerating Their Investment Outlays Regardless of Economic Justifications,* at 4-6, 8-9 (attached to Letter from Brian R. Moir, Fisher, Wayland, Cooper and Leader, to William F. Maher, Jr., NTIA (May 3, 1991)); Roddy, *Analysis of DRI/McGraw Hill Telecommunications Infrastructure Report: "The Contribution of Telecommunications Infrastructure to Aggregate and Sectoral Economic Efficiency"* (submitted as Attachment B to Supplemental Comments of ICA). For DRI's response to these criticisms, see Cronin, *Response to Economics and Technology, Inc. Criticisms of "The Contribution of Telecommunications Infrastructure to Aggregate and Sectoral Economic Efficiency"* (attached to Letter from Christopher W. Savage, Bell Atlantic, to William F. Maher, Jr., NTIA (Jan. 11, 1991)).

[1175] Supplemental Comments of ICA at 3.

II. FINDING #1: THE RESOURCE SAVINGS RESULTING FROM TELECOMMUNICATIONS INVESTMENT

As noted above, DRI's first principal finding is that "investments in and use of telecommunications have dramatically—and positively—affected production processes throughout the economy."[1176] Specifically, DRI's analysis concludes that, in 1982, the U.S. economy "saved $81.3 billion in labor and capital expenses because (1) the telecommunications industry itself improved the efficiency of its production process and (2) the consuming industries increased their per-unit usage of telecommunications at the expense of more costly, less efficient substitutes."[1177] Our examination of this finding begins with a description of the methodology DRI used to derive the estimated resource savings, followed by an examination of that methodology and DRI's interpretation of its results.

A. DRI's Methodology

DRI employs input-output analysis in an effort to quantify the improvements in the economy's productivity attributable to changes in the production and consumption of telecommunications services (and, implicitly, to investment in telecommunications infrastructure). In input-output analysis, the economy is broken down into industries (or sectors), and the flow of goods and services among the industries is registered to indicate systematically the relationships among them. These relationships are called input-output relations because they describe a set of resource inputs used to produce the economy's output.

In principle, DRI's approach is straightforward. The first step involves estimating the cost of the resource inputs consumed in satisfying the production demands of the U.S. economy in 1982. The second step involves reducing the efficiency with which inputs are consumed, and then determining the resource cost associated with satisfying those same 1982 output or production demands. Finally, the resulting "resource savings" are calculated by subtracting the latter estimate from the former.[1178]

[1176] *DRI Study, supra* note 1168, at 2.

[1177] *Id.* at 15.

[1178] Because the second step involves reducing the efficiency with which telecommunications services are both produced and consumed, the latter estimate will necessarily be larger than the former estimate, thus producing a "savings."

The details of the input-output analysis can be illustrated by a simple example.[1179] Suppose the U.S. economy is composed of two industries: telecommunications and manufacturing. Moreover, suppose that the input-output coefficients for the year 1982, which indicate the quantity of industry i (either telecommunications or manufacturing) input "consumed" per unit output of industry j (again, either telecommunications or manufacturing), are as follows:

$$A = \begin{array}{cc} \text{Input} \diagdown & \begin{array}{cc} \multicolumn{2}{c}{\text{Output}} \\ T & M \end{array} \\ \begin{array}{c} T \\ M \end{array} & \begin{bmatrix} .3 & .4 \\ .2 & .2 \end{bmatrix} \end{array}$$

where the rows and columns are defined as the telecommunications (T) and manufacturing (M) industries, respectively.[1180] According to matrix A, therefore, .3 units of telecommunications services are needed to produce one unit of telecommunications services, and .4 units of telecommunications services are needed to produce one unit of manufacturing product.[1181]

Suppose, further, that capital and labor are the only primary inputs[1182] used by the telecommunications and manufacturing industries in their production processes and that the input-output coefficients for these inputs in 1982 are as follows:

[1179] The DRI model was considerably more elaborate than our simple example. For instance, DRI used a total of 29 industries in its model. Nonetheless, our simplified two-industry model is sufficient to describe DRI's basic methodology.

[1180] The above matrix is a "technical" input-output matrix. The word "technical" is used because the technology of production is clearly displayed. The elements of the matrix $[a_{ij}]$ indicate the amount of product i needed to produce one unit of product j.

[1181] This example assumes that the telecommunications sector consumes some of its own output (*e.g.*, an interexchange carrier may use its own long distance service as an input in producing long distance service). There is a limit, however, to the extent to which an industry can consume its own product. If the coefficient were equal to 1.0, all output of the telecommunications sector would be consumed in its production process, leaving none left for sale. Since the amount left for sale is the source of revenues for the telecommunications industry, there would be no production of telecommunications services.

[1182] There are two kinds of inputs: intermediate and primary. Intermediate inputs are outputs from one industry that are used by other industries in producing their products. A primary input is an input that is typically not an output of some other industry. For example, the silicon chips used to manufacture computers are intermediate inputs. A classic example of a primary input is labor.

$$B = \begin{array}{cc} & \begin{array}{cc} T & M \end{array} \\ \begin{array}{c} K \\ L \end{array} & \begin{bmatrix} .2 & .1 \\ .1 & .1 \end{bmatrix} \end{array}$$

where the rows refer to the amount of capital (K) and labor (L) consumed by the telecommunications (T) and manufacturing (M) sectors, respectively, in producing their outputs. Thus, for example, .2 units of capital are needed to produce one unit of telecommunications service. Similarly, .1 units of labor are needed to produce one unit of manufacturing product.

In order to derive a monetary value for the resource inputs consumed in producing telecommunications and manufacturing outputs, the coefficients in matrices A and B must be converted from physical units to dollar units. This conversion is accomplished by making an assumption about the prices of the inputs and outputs considered.[1183] In our example, for purposes of simplicity, let the price of each unit of telecommunications service, manufacturing product, labor, and capital be $1.00.[1184] The conversion of the various input-output coefficients from physical units into dollar units means that, as indicated in matrix A, .3 dollars of telecommunications services are needed to produce one dollar of telecommunications services. Similarly, as indicated in matrix B, .1 dollars of capital are needed to produce one dollar of manufacturing product.

Finally, suppose that the vector of final demands (measured in billions of dollars) to be satisfied by telecommunications and manufacturing in our example is as follows:

$$\bar{d} = \begin{array}{cc} T \\ M \end{array} \begin{bmatrix} 10 \\ 5 \end{bmatrix}$$

The vector of final demands represents the "final" sales of the telecommunications services and manufacturing product to consumers, investors, government, and net exports.

[1183] The fundamental conclusions of this analysis are not sensitive to the prices chosen.

[1184] For simplicity, we also assume that there is no inflation, so that nominal and real dollars are the same during the time period considered. The fundamental conclusions of this analysis are not sensitive to this assumption.

Input-output analysis can be used to determine the monetary value (which we denote as v) of the primary inputs required to satisfy the above vector of final demands. This can be obtained by the following two-step procedure: First, total output for each industry (telecommunications and manufacturing), represented by vector $\vec{x}$, equals the vector of final demands plus the amount of resources consumed by the industry itself, or:

$$\text{(1)} \qquad \vec{x} = \vec{d} + A\vec{x}$$

where A is the matrix of input-output coefficients for telecommunications and manufacturing described earlier, and $\vec{d}$ is the vector of final demands. The total output vector can be obtained by manipulating Eq. (1) to yield:

$$\text{(2)} \qquad (I - A)^{-1} \cdot \vec{d} = \vec{x}$$

where I is the "identity" matrix,[1185] and where all other variables are defined as before.[1186]

The second step involves multiplying the monetary value of each industry's output by the quantity of primary inputs consumed in producing that output, as indicated in Eq. (2):

$$\text{(3)} \qquad B \cdot \vec{x} = \vec{v} \quad \text{(value)}$$

where B is a matrix of input-output coefficients and $\vec{x}$ is the vector of total industry output as derived from Eq. (1). Eq. (3) calculates the dollar value of the primary resources (capital and labor) used in both industries to satisfy the vector of final demands. The total dollar value of the primary resources consumed is obtained by summing the resource totals for both industries.[1187] Applying the three equations to the values posited in our example, we find that in satisfying the assumed final demand, our two-sector economy consumes $8.542 billion in capital and labor input.

[1185] An "identity" matrix is a square matrix with 1s in its principal diagonal and 0s elsewhere. Its role in matrix algebra is similar to that of the number 1 in the algebra of numbers.

[1186] Note, again, that the coefficients in matrix A and the vector of final demands are expressed in dollars.

[1187] For DRI's explanation of this part of its methodology, see Letter from Mark Gold, DRI, to Mark Bykowsky, NTIA (Mar. 26, 1991) (on file with NTIA).

The next part of DRI's methodology involves creating a hypothetical economy whose production relationships answers the following question: what is the monetary value of the primary inputs that would have been consumed in satisfying the economy's 1982 vector of final demands if telecommunications firms had not invested in infrastructure? DRI created such an economy by following a two-step procedure. In the first step, DRI replaced the 1982 input-output coefficients in matrix A for telecommunications by their 1963 values.[1188] This substitution accomplishes two things: First, it imposes the restriction that the telecommunications industry consume inputs in the same way that it did in 1963. In effect, it imposes the 1963 production technology and factor prices on the telecommunications industry. Second, the substitution imposes the restriction that telecommunications end-users consume the same quantity of telecommunications input that they did in 1963.

In the second step, DRI altered a number of the input-output coefficients for the other industries it included in its analysis, based on the assumption that changes in the quantity of telecommunications inputs used will induce a change in the quantity of other inputs used.[1189] In our example, this is equivalent to changing any technical input-output coefficient located southeast of the first row and column. Following this change, the A and B matrices are now defined as:

$$A = \begin{array}{cc} & \begin{array}{cc} T & M \end{array} \\ \begin{array}{c} T \\ M \end{array} & \begin{bmatrix} .2* & .3* \\ .4* & .3* \end{bmatrix} \end{array}$$

$$B = \begin{array}{cc} & \begin{array}{cc} T & M \end{array} \\ \begin{array}{c} K \\ L \end{array} & \begin{bmatrix} .2 & .1 \\ .1 & .1 \end{bmatrix} \end{array}$$

[1188] In our example, this is equivalent to changing the first row and column of matrix A.

[1189] The substitution, in essence, imposes 1963 factor prices on end-users. Since the manner in which a firm combines inputs is a function of their relative prices, certain adjustments were made to the other input-output coefficients. According to DRI, these adjustments were based upon a series of industry-specific trans-log cost models. *See DRI Study, supra* note 1168, at 32-34, C.1-C.11.

where the asterisks indicate changed coefficients.[1190] DRI then apparently calculated, using equations (2) and (3) and 1963 input-output coefficients, the monetary value of primary inputs required to satisfy the 1982 vector of final demands. In our example, that figure is $9.432 billion. According to DRI, the difference between the value of the primary inputs used to satisfy the vector of final demand in the "real" 1982 economy and the "hypothetical" 1982 economy (in our example, $9.432 billion minus $8.542 billion, or $890 million) represents the resource savings associated with telecommunications infrastructure investment between 1963 and 1982.

B. Analysis of DRI's Resource Savings Methodology

The principal advantage of DRI's methodology is its attempt to capture the productivity gains in both the production and consumption of telecommunications services due to telecommunications infrastructure investment. Nonetheless, some aspects of DRI's methodology call into question the reliability of the estimated resource savings associated with these productivity gains.

1. Linkage of Estimated Resource Savings to Investment in Telecommunications Infrastructure

DRI does not firmly establish that the savings it estimates due to improved production and increased consumption of telecommunications are attributable solely to investments in telecommunications infrastructure. For example, factors such as telecommunications infrastructure or investment are not quantified and play no explicit role in DRI's resource savings methodology.[1191] For this reason, the study cannot be used to conclude, without further analysis, that its estimated resource savings are due solely to changes in the stock of telecommunications infrastructure.

[1190] Observe that the first step in the methodology causes a change in the first column and row of matrix A. The second step causes a change in coefficients southeast of the first row and column. Because we are using a two-industry example, all coefficients in matrix A must therefore be changed.

[1191] In an effort to improve the model's linkage between telecommunications infrastructure investment and its resource savings, DRI examines whether there is a causal relationship between telecommunications infrastructure investment and two different measures of economic growth. Presumably, if there is such a relationship, DRI believes it can reasonably conclude that productivity improvements since 1963 (as demonstrated by the resource savings that DRI identifies) are also due to telecommunications infrastructure investment. As noted above, however, economic growth does not necessarily imply an increase in productivity. Thus, a causal linkage between telecommunications investment and economic growth does not establish any necessary causal relationship between such investment and productivity gains. Moreover, as discussed below, DRI's attempt to identify a positive cause and effect relationship between telecommunications investment and economic growth is not entirely successful.

The calculated resource savings could be attributed to telecommunications infrastructure investment if such investment were the sole cause for the changes in telecommunications production efficiency and telecommunications usage between 1963 and 1982 (as reflected, over the same period, in the coefficients in DRI's input-output matrices). However, those coefficients could be affected by a number of factors that are unrelated to telecommunications infrastructure investment.

First, changes in relative prices of inputs will cause a firm to alter the mix of inputs used in its production process, substituting relatively cheaper inputs for relatively more expensive inputs.[1192] The effects of this substitution will appear as a change in the value of the input-output coefficients over time.

Second, the input-output coefficients would be affected by economies of scale made possible by demand growth.[1193] With economies of scale, the average unit cost of producing a product declines as the level of output increases. This implies that the relative amount of at least one input required to produce a unit of output declines as output increases. Therefore, with an increase in demand, economies of scale, to the extent they exist, will result in a change in the observed input-output coefficients.[1194]

Third, because of computational and data gathering considerations, input-output analysis combines similar industries to form more aggregated industry classifications. An industry's input-output coefficients, therefore, indicate the average amount of product i needed to produce one unit of product j for a collection of sub-industries. Since input requirements differ across industries, the inclusion of a "new" industry into an existing collection of industries will cause a change in the input-output coefficients. For example, cable television was not included in DRI's definition of "telecommunications" in 1963, but it was included in the definition for 1982.[1195] Because of differences in cable television and telephony input requirements, the change in this definition of "telecommunications" will cause a change in the telecommunications industry's input-output coefficients.[1196]

[1192] As discussed earlier, *supra* note 1189, DRI does attempt to take into account, in its hypothetical economy, the change in relative prices stemming from its use of the 1963 input-output coefficients for the telecommunications industry. However, it is not possible to adjust the telecommunications industry's input-output coefficients to take into account changes in relative input prices.

[1193] One source of economies of scale is the existence of a fixed cost. In the telecommunications industry, fixed costs are those costs that are insensitive to the volume of telephone traffic carried. In the short-run, one can loosely equate these costs to a given level of "infrastructure."

[1194] Similarly, economies of scope will also cause a change (*i.e.*, reduction) in the observed input-output coefficients

Fourth, the coefficients can vary over time because of changes in consumer demand, independent of the amount telecommunications infrastructure investment.[1197] For example, real estate agents may substitute cellular telephone service for automobile travel. This substitution may require cellular providers to consume more microelectronics relative to other inputs, without requiring any additional investment. Thus, a change in the composition of telecommunications service demand will cause a change in the telecommunications industry's input-output coefficients.

Fifth, increases in investment made by upstream firms providing inputs to the telecommunications industry may change the telecommunications industry's input-output coefficients.[1198] DRI, however, does not attempt to remove from its resource savings estimate these technological spillovers. As a result, it is unclear what portion of the total resource savings estimated by DRI is attributable to telecommunications infrastructure investment. According to DRI this "separation" is not necessary because its analysis "seeks to compare production efficiencies between an economy with a modern telecommunications infrastructure and an economy without one."[1199] The analysis should, however, identify the contribution made by telecommunications infrastructure investment to aggregate productivity growth. The telecommunications infrastructure debate centers on the issue of whether telecommunications service providers have sufficient incentive to invest in infrastructure. Providing them with greater incentives through, for example, changes in regulatory policy may have little effect if a majority of the productivity gains are due to investments made by upstream firms.

[1195] *See* Memorandum from Mark Gold, DRI, to Mark Bykowsky, NTIA (Apr. 5, 1991) (on file with NTIA).

[1196] DRI states that since it did not, for instance, "hedonically" adjust the 1982 output relative to that of 1963, the inclusion of cable television will lead to an underestimate of the resource savings attributable to "productive efficiency." *See id.* at 2. While DRI's assertion is correct, these additional resource savings exist solely because of a redefinition of the term "telecommunications," not because of resource savings attributable to telecommunications infrastructure investments.

[1197] Input-output coefficients have also changed over time because of estimation improvements. Because of improvements in the quality of data collected by, for example, the Bureau of the Census, the Department of Commerce has increased the accuracy of its input-output coefficients.

[1198] *See* Roddy, *A Summary of the Debate over Statistical Models Used by the Regional Bell Operating Companies in Support of Accelerating Their Investment Outlays Regardless of Economic Justifications*, at 6 (attached to Letter from Brian R. Moir, Fisher, Wayland, Cooper and Leader, to William F. Maher, Jr., NTIA (May 3, 1991)).

[1199] *See* Cronin, *Response to Economics and Technology, Inc. Criticisms of "The Contribution of Telecommunications Infrastructure to Aggregate and Sectoral Economic Efficiency"* at 3 (attached to Letter from Christopher W. Savage, Bell Atlantic, to William F. Maher, Jr., NTIA (Jan. 11, 1991)).

Finally, changes in the input-output coefficients for the telecommunications industry may be attributable to non-infrastructure-related investments. For example, a firm typically invests in "organizational improvements" in order to introduce organizational "innovations" into the firm. Such investment stems from addressing internal operating issues that emerge as firms within an industry increase in size and complexity.[1200] These investments will likely alter the manner in which the firm combines inputs, and therefore, change the firm's input-output coefficients, independent of investment in the telecommunications facilities that make up the infrastructure.

Thus, the DRI study does not definitively establish that the changes in the relevant input-output coefficients between 1963 and 1982 (which, in turn, were used to estimate the resource savings realized over that period) were solely attributable to telecommunications infrastructure investment. This does not mean, of course, that there is no link between such investment and the resource savings estimated. It simply means that some of those savings may also be attributable to other factors.

2. Methodological Issues

Input-output analysis imposes a number of restrictions on the values of the input-output coefficients. For example, the columns in matrices A and B defined above describe the input or cost structure of the telecommunications and manufacturing industries, respectively. According to the first or "base" case, it takes .3 dollars of telecommunications services, .2 dollars of manufacturing services, .2 dollars of capital, and .1 dollars of labor to produce 1.0 dollar worth of telecommunications services. It takes, therefore, .8 dollars worth of inputs to produce 1.0 dollars worth of telecommunications services. The remaining .2 dollars (1.0 dollar - .8 dollars) represents the telecommunications firm's per unit profit. However, as a systematic summary of the overall economic activities of the economy, input-output analysis must account for the .2 dollars of per unit profit. Input-output analysis does so with the use of a row (or rows) in matrix B that captures all "value added."[1201]

[1200] *See* O. Williamson, *Markets and Hierarchies: Analysis and Antitrust Implications* Chapters 8 and 9 (1975).

The input-output matrices will record all the economic activities of our simplified economy if the sum of the input-output coefficients in each column of matrix A, plus the corresponding column sum of matrix B equals 1.0.[1202] In our example, this "column sum constraint" means that the "total" input cost (the input cost of intermediate and primary inputs (*i.e.*, value added)) incurred in producing a dollar's worth of some commodity should be equal to the revenue the industry earns from producing a dollar's worth of its product (*i.e.*, 1.0 dollar). In more general terms, the column sum constraint means that the total payments made to the factors of production in the economy (including value added) should be equal to the total revenue of the economy. To the extent that the column sum constraint is not satisfied, an input-output model does not describe all of the interdependencies of the industries modeled. Its value, therefore, is severely weakened because it will not measure the effect of a change in, for example, final consumption or technological innovation on the profitability of those industries.

DRI's input-output analysis does not satisfy this condition. Table C.1 presents six groups of A and B matrices, with each pair of matrices depicting a different production scenario. Cases 1 and 2 were used earlier to describe the DRI methodology. For expository purposes, suppose Case 1 is the "base" model, and the remaining cases are "hypothetical" models in that we have replaced the telecommunications industries' 1982 input-output coefficients with their 1963 counterparts and have adjusted other coefficients to reflect this substitution. In each case, we have calculated the monetary value of capital and labor required to produce the satisfy the same vector of final demands for 1982 (*i.e.*, $10 billion of telecommunications services and $5 billion of manufacturing product).

Observe that in the two instances where the corresponding columns of matrices A and B sum to 1.0, the monetary value of the primary inputs consumed is insensitive to the

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[1201] The term "value added" represents payments made to all primary inputs. This includes wage payments, depreciation (cost of using capital equipment), business taxes, rent, interest, and profit or loss. *See* C. Yan, *Introduction to Input-Output Economics* 49 (1968).

[1202] Formally, this requirement is equivalent to the following condition:

$$\sum_i (a_{ij} + b_{ij}) = 1.0$$

where the summation is over i, that is, over the elements appearing in the various rows of a specific column j (where j = telecommunications and manufacturing) in matrices A and B. This condition states that each column sum in matrices A and B must, when added together, equal 1.0.

value of the coefficients in the A and B matrices (Cases 5 and 6). If, therefore, Case 5 was the base case and Case 6 was the "hypothetical," a resource savings would not

Case #1 ("Base")	**Case #2**	**Case #3**
$A = \begin{bmatrix} .3 & .4 \\ .2 & .2 \end{bmatrix}$	$A = \begin{bmatrix} .2 & .3 \\ .4 & .3 \end{bmatrix}$	$A = \begin{bmatrix} .2 & .3 \\ .3 & .3 \end{bmatrix}$
$B = \begin{bmatrix} .2 & .1 \\ .1 & .1 \end{bmatrix}$	$B = \begin{bmatrix} .2 & .1 \\ .1 & .1 \end{bmatrix}$	$B = \begin{bmatrix} .2 & .1 \\ .2 & .1 \end{bmatrix}$
$\overset{\text{Col}}{\Sigma} = \begin{bmatrix} .8 & .8 \end{bmatrix}$	$\overset{\text{Col}}{\Sigma} = \begin{bmatrix} .9 & .8 \end{bmatrix}$	$\overset{\text{Col}}{\Sigma} = \begin{bmatrix} .9 & .8 \end{bmatrix}$
Resource Cost = \$8.542 Billion	Resource Cost = \$9.432 Billion	Resource Cost = \$10.213 Billion
Case #4	**Case #5**	**Case #6**
$A = \begin{bmatrix} .2 & .4 \\ .3 & .1 \end{bmatrix}$	$A = \begin{bmatrix} .2 & .4 \\ .3 & .1 \end{bmatrix}$	$A = \begin{bmatrix} .1 & .3 \\ .4 & .2 \end{bmatrix}$
$B = \begin{bmatrix} .3 & .1 \\ .1 & .1 \end{bmatrix}$	$B = \begin{bmatrix} .3 & .3 \\ .2 & .2 \end{bmatrix}$	$B = \begin{bmatrix} .3 & .3 \\ .2 & .2 \end{bmatrix}$
$\overset{\text{Col}}{\Sigma} = \begin{bmatrix} .9 & .7 \end{bmatrix}$	$\overset{\text{Col}}{\Sigma} = \begin{bmatrix} 1.0 & 1.0 \end{bmatrix}$	$\overset{\text{Col}}{\Sigma} = \begin{bmatrix} 1.0 & 1.0 \end{bmatrix}$
Resource Cost = \$9.667 Billion	Resource Cost = \$15.000 Billion	Resource Cost = \$15.000 Billion

Table C.1: Hypothetical Input-Output Matrices

appear because the total value of the primary resources consumed would be the same in the two cases. It can easily be shown that in all cases where the "column sum constraint" is satisfied, such a "resource savings" could not occur. Consequently, DRI could only obtain a "resource savings" if it did not satisfy the condition that the sum of the input-output coefficients in each column of matrix A (the "column sum"), plus the corresponding column sum of matrix B, equal 1.0.

Because the total value of the primary resources consumed is greatest when the column sum constraint is satisfied, a "resource savings" can only occur if the column sum constraint is more closely satisfied (*i.e.*, the column sum is closer to 1.0) in the hypothetical model than in the base, 1982 model (compare Case 1 with all other cases). It is unclear why one or both models should not satisfy the column sum constraint.

DRI provides two reasons why the column sum constraint will not hold. First, DRI states that because it is comparing input-output tables from two different years, the coefficients in those tables must be expressed in the same "real" terms to permit a meaningful comparison. DRI states that as a result of this transformation, the columns in these tables "will not, in general, sum to one."[1203] Second, DRI asserts that, by reducing certain input-output coefficients, technological change will cause the column sums of the input-output tables to move "farther and farther from one."[1204] However, we question the validity of these explanations, which both posit a reduction in the relevant input-output coefficients. In either case, because of the accounting identity requirement that the dollar cost of production in the telecommunications industry (including value added) must be equal to the industry's revenue, a reduction in those coefficients should be offset by a compensating increase in value added. In our hypothetical case, for example, a reduction in the coefficients in the intermediate input-output matrix A should be fully compensated by an increase in the coefficients in the primary input-output matrix B. This means that the resource savings the industry realizes by a reduction in its input-output coefficients should be offset by an increase in payments made to capital and labor (*i.e.*, an increase in value added).[1205]

[1203] Letter from Francis J. Cronin, DRI, to Timothy Sloan, NTIA, at 3 (Sept. 24, 1991) (DRI Letter) (emphasis in original omitted).

[1204] *Id.* at 4 (emphasis in original omitted).

[1205] We emphasize that we are not criticizing input-output analysis as an analytical tool. Rather, our critique is limited to the manner in which input-output analysis has been modified to derive an estimate of the resource savings associated with telecommunications infrastructure investment.

Taken together, therefore, the methodological problems in DRI's study call into question the accuracy of the estimated resource savings attributable to telecommunications infrastructure investment.

3. The Analysis Does Not Examine Costs

Sound infrastructure investment policy requires that investment decisions be based on economically efficient investment principles. At the minimum, this requires that decisions concerning telecommunications investment be based on both the likely benefits and costs of such investment.[1206] Only then can it be determined whether investment in telecommunications infrastructure will produce a net gain to society. Because DRI's analysis examines only the putative benefits of telecommunications investment, its lessons for policymakers are inconclusive.

III. FINDING #2: THE CAUSAL RELATIONSHIP BETWEEN TELECOMMUNICATIONS INVESTMENT AND ECONOMIC GROWTH

The second objective of the DRI study is to examine the direction of "causality" between economic growth and telecommunications infrastructure investment. This examination attempts to provide an indirect assessment of whether it is economically desirable to provide telecommunications firms added incentive to invest in infrastructure.[1207] In describing its analysis, DRI cautions against drawing unfounded inferences from its causality analysis.[1208]

DRI's study adopted the Granger definition of "causality," which provides that Y is said to be "caused" by X if X helps predict future changes in Y.[1209] The Granger causality test is performed by estimating two equations. The first equation contains the presumed "causal" variable; the second is estimated without that variable.[1210] An F-test is used to determine whether the introduction of the "causal" variable improves the "forecastibility" of the model.[1211]

[1206] Specifically, investments in infrastructure should be made up to the point at which their marginal benefits equal their marginal costs.

[1207] As noted earlier, *supra* note 1173, economic growth does not necessarily imply either productivity growth or improvement in living standards. For this reason, an analysis that perhaps would be more useful could test the causal relationship between telecommunications investment and economy-wide Total Factor Productivity (TFP).

[1208] *See* DRI Letter, *supra* note 1203, at 3; *DRI Study, supra* note 1168, at F.6.

[1209] *See DRI Study, supra* note 1168, at F.3.; C. Granger and P. Newbold, *Forecasting Economic Time Series* 224 (1977).

Granger causality takes two forms. If X causes Y and Y does not cause X, then there exists "unidirectional" causality. If X causes Y and Y causes X, then there exists "bidirectional" causality. Bidirectional causality implies that both X and Y are mutually dependent. Under this condition, it is impossible to attribute changes in Y to changes in X, and *vice versa*. The most that can be inferred is that both variables influence each other.

DRI asserts that its causality analysis "strongly suggests that increased telecommunications investment and usage causes (in a statistical sense, is a good predictor of) economic growth in later years."[1212] This statement overstates the results of that analysis, for two reasons.[1213] First, because DRI's analysis is based on data that have been first differenced,[1214] the estimated coefficients measure, roughly speaking, how changes in the growth rate of infrastructure investment affect changes in the growth rate of GNP, and *vice versa*. DRI's conclusion that telecommunications investment causes output growth thus misstates its analysis.

[1210] The statistical test for Granger causality also requires that each model's disturbance term is "white noise" (*i.e.*, absence of serial correlation). In general, this requires that the raw data for both variables (assuming a bivariate model) be transformed with the use of a "prefilter." DRI used a first-difference prefilter (*i.e.*, (1-B)), where B is a backshift operator that shifts the subscript of a time series observations backward in time by one period. *See* Kang, *The Optimal Lag Selection and Transfer Function Analysis in Granger Causality Tests,* 13 J. of Econ. Dynamics and Control 154 (1989).

[1211] In order for the F-test to be valid, the disturbance term in the respective models must be normally distributed. At NTIA's request, DRI provided the results of a Chi-square test that examined the normality of the disturbance term in each of its causality models. The results indicate that those disturbance terms are in fact normally distributed. We note, however, that the Chi-square test is one of the weakest of the six tests commonly used to determine the normality of disturbance terms in regression models. *See* Huang and Bolch, *On the Testing of Regression Disturbances for Normality,* 69 J. Am. Stat. Ass'n 330 (1974).

[1212] *DRI Study, supra* note 1168, at viii.

[1213] DRI has been unduly criticized for its use of a 10 percent level of significance, rather than, for example a 5 percent level, in evaluating its F-tests. *See* Roddy, *Analysis of DRI/McGraw Hill Telecommunications Infrastructure Report: "The Contribution of Telecommunications Infrastructure to Aggregate and Sectoral Economic Efficiency"* at 4 (submitted as Attachment B to Supplemental Comments of ICA). The choice of significance level to be used typically lies within the discretion of the experimenter. In brief, selection of the significance level should be based on the expected losses associated with "Type 1" (*i.e.*, rejection of a "true" null hypothesis) and "Type 2" (acceptance of a "false" null hypothesis) errors. Once these losses are estimated, the experimenter should then weigh, in some manner, the importance of these losses in selecting the size of the significance level. In selecting a 10 percent level of significance, DRI implicitly assumes that the cost of making a Type 2 error (*i.e.*, concluding that there is no relationship between economic growth and telecommunications infrastructure investment when, in fact, there is) exceeds the cost of committing a Type 1 error (*i.e*, concluding that there is a relationship between economic growth and telecommunications investment when, in fact, there is not).

Second, Granger causality analysis is typically used to test for the "exogeneity" of variables used in the construction of economic models.[1215] In these instances, the sign of the variable being tested is not commonly considered because of the possibility of "specification error."[1216] What is important is the degree to which the two variables are statistically related, rather than whether that relationship is positive or negative. In order to determine the nature of the relationship, one would then have to estimate a "reduced form model" that includes all relevant exogenous variables.[1217] Because the analysis has not taken this second step, it can not properly draw any inferences regarding the nature of the causal relationship.[1218]

[1214] First differencing involves subtracting the value of a particular variable in one year from its value in a later year.

[1215] *See* Sims, *Money, Income and Causality*, 62 Am. Econ. Rev. 540 (1972). A variable is "exogenous" if its values are determined by forces external to the estimated model. More formally, the values of exogenous variables depend on variables that are not related to the "endogenous" variables of the model, or to the model's disturbance term. Endogenous variables are variables whose values are determined through the joint interaction with other variables in the system. *See* G. Judge, *et al.*, *Introduction to the Theory and Practice of Econometrics*, Chapter 12 (1982).

[1216] "Specification error" refers to the error associated with either omitting a relevant variable from a model or including an irrelevant variable or employing an inappropriate functional form. Unless the dependent variable is completely described by an autoregressive process, the model specification used in the Granger causality will lead to specification error. Specifically, a bias associated with omitting relevant variables will occur, thereby producing unreliable coefficient estimates. For a discussion of specification error, see G. Maddala, *Econometrics* 155 (1977).

[1217] A "reduced form model" is one in which one or more endogenous variables is described purely in terms of a set of exogenous (or predetermined) variables.

[1218] Additionally, we note that the variables being tested for causality have both positive and negative signs. *See infra* at C-18 to C-26. Although DRI cautions against drawing conclusions from the negative signs associated with many of the variables being tested, it nevertheless offers an explanation for those signs. Specifically, DRI states that each negative sign "simply reflects the extent to which the two series [*i.e.*, telecommunications investment and economic growth] are out of phase." DRI Letter, *supra* note 1203, at 3 (emphasis in original omitted). The analysis does not explain why the out-of-phase relationship cited exists at all, nor does it test the validity of the assumption that this out-of-phase relationship is the cause of the negative signs.

CAUSALITY ANALYSIS
GRANGER'S TEST

TESTING TOTAL OUTPUT CAUSING TELECOMM INVESTMENT
(performed using first differencing)

ORDINARY LEAST SQUARES
ANNUAL(1958 TO 1988) 31 OBSERVATIONS (3 OMITTED)
DEPENDENT VARIABLE: TELECOMM INVESTMENT
DATES OF OMITTED DATA: 1958 TO 1960

	COEFFICIENT	STD. ERROR	T-STAT	INDEPENDENT VARIABLE
	0.681018	0.2723	2.501	CONSTANT
1	0.361796	0.1696	2.133	TELECOMM INVESTMENT LAG 1
2	-0.539466	0.1731	-3.116	TELECOMM INVESTMENT LAG 2

R-BAR SQUARED: 0.2669
DURBIN-WATSON STATISTIC: 2.0403
STANDARD ERROR OF THE REGRESSION: 1.271 NORMALIZED: 2.290

ORDINARY LEAST SQUARES
ANNUAL(1958 TO 1988) 31 OBSERVATIONS (3 OMITTED)
DEPENDENT VARIABLE: TELECOMM INVESTMENT
DATES OF OMITTED DATA: 1958 TO 1960

	COEFFICIENT	STD. ERROR	T-STAT	INDEPENDENT VARIABLE
	0.554998	0.4041	1.373	CONSTANT
1	0.324153	0.2108	1.538	TELECOMM INVESTMENT LAG 1
2	-0.167631	0.2201	-0.7617	TELECOMM INVESTMENT LAG 2
3	0.00395503	0.002197	1.800	TOTAL OUTPUT LAG 1
4	-0.00466438	0.002326	-2.006	TOTAL OUTPUT LAG 2

R-BAR SQUARED: 0.3703
DURBIN-WATSON STATISTIC: 2.0960
STANDARD ERROR OF THE REGRESSION: 1.178 NORMALIZED: 2.123

Table C.2: DRI Causality Tests
(Table continues on next page)

TESTING TELECOMM INVESTMENT CAUSES TOTAL OUTPUT

(performed using first differencing)

ORDINARY LEAST SQUARES
ANNUAL(1958 TO 1988) 31 OBSERVATIONS (3 OMITTED)
DEPENDENT VARIABLE: TOTAL OUTPUT
DATES OF OMITTED DATA: 1958 TO 1960

	COEFFICIENT	STD. ERROR	T-STAT	INDEPENDENT VARIABLE
	159.730	40.59	3.935	CONSTANT
1	0.287282	0.1831	1.569	TOTAL OUTPUT LAG 1
2	-0.408580	0.1861	-2.196	TOTAL OUTPUT LAG 2

R-BAR SQUARED: 0.1363
DURBIN-WATSON STATISTIC: 2.1069
STANDARD ERROR OF THE REGRESSION: 131.1 NORMALIZED: 0.9089

ORDINARY LEAST SQUARES
ANNUAL(1958 TO 1988) 31 OBSERVATIONS (3 OMITTED)
DEPENDENT VARIABLE: TOTAL OUTPUT
DATES OF OMITTED DATA: 1958 TO 1960

	COEFFICIENT	STD. ERROR	T-STAT	INDEPENDENT VARIABLE
	127.412	42.85	2.973	CONSTANT
1	0.494911	0.2329	2.125	TOTAL OUTPUT LAG 1
2	-0.178141	0.2466	-0.7224	TOTAL OUTPUT LAG 2
3	-46.9246	22.35	-2.100	TELECOMM INVESTMENT LAG 1
4	0.301282	23.33	0.01291	TELECOMM INVESTMENT LAG 2

R-BAR SQUARED: 0.2168
DURBIN-WATSON STATISTIC: 2.1323
STANDARD ERROR OF THE REGRESSION: 124.9 NORMALIZED: 0.8655

CRITICAL F VALUE WITH 2 AND 26 DEGREES OF FREEDOM AT THE TEN PERCENT LEVEL = 2.519
TOTAL OUTPUT CAUSES TELECOMM INVESTMENT FVALUE: 3.451
TELECOMM INVESTMENT CAUSES TOTAL OUTPUT FVALUE: 2.583

All series deflated to 1982 dollars.

Table C.2: DRI Causality Tests
(Table continues on next page)

CAUSALITY ANALYSIS
GRANGER'S TEST

TESTING GNP CAUSES TELECOMM INVESTMENT

(performed using first differencing)

ORDINARY LEAST SQUARES
ANNUAL(1958 TO 1988) 31 OBSERVATIONS (3 OMITTED)
DEPENDENT VARIABLE: **TELECOMM INVESTMENT**
DATES OF OMITTED DATA: 1958 TO 1960

	COEFFICIENT	**STD. ERROR**	**T-STAT**	**INDEPENDENT VARIABLE**
	0.681018	0.2723	2.501	CONSTANT
1	0.361796	0.1696	2.133	TELECOMM INVESTMENT LAG 1
2	-0.539466	0.1731	-3.116	TELECOMM INVESTMENT LAG 2

R-BAR SQUARED: 0.2669
DURBIN-WATSON STATISTIC: 2.0403
STANDARD ERROR OF THE REGRESSION: 1.271 NORMALIZED: 2.290

ORDINARY LEAST SQUARES
ANNUAL(1958 TO 1988) 31 OBSERVATIONS (3 OMITTED)
DEPENDENT VARIABLE: **TELECOMM INVESTMENT**
DATES OF OMITTED DATA: 1958 TO 1960

	COEFFICIENT	**STD. ERROR**	**T-STAT**	**INDEPENDENT VARIABLE**
	0.774200	0.4191	1.847	CONSTANT
1	0.358380	0.1831	1.957	TELECOMM INVESTMENT LAG 1
2	-0.154843	0.1858	-0.8333	TELECOMM INVESTMENT LAG 2
3	0.00860285	0.004036	2.131	GNP LAG 1
4	-0.0130064	0.004368	-2.977	GNP LAG 2

R-BAR SQUARED: 0.4693
DURBIN-WATSON STATISTIC: 1.9543
STANDARD ERROR OF THE REGRESSION: 1.081 NORMALIZED: 1.949

Table C.2: DRI Causality Tests
(Table continues on next page)

TESTING TELECOMM INVESTMENT CAUSES GNP

(performed using first differencing)

ORDINARY LEAST SQUARES
ANNUAL(1958 TO 1988) 31 OBSERVATIONS
DEPENDENT VARIABLE: GNP
DATES OF OMITTED DATA: 1958 TO 1960

	COEFFICIENT	STD. ERROR	T-STAT	INDEPENDENT VARIABLE
	74.6888	20.43	3.656	CONSTANT
1	0.319609	0.1863	1.716	GNP LAG 1
2	-0.265851	0.1871	-1.421	GNP LAG 2

R-BAR SQUARED: 0.0637
DURBIN-WATSON STATISTIC: 1.9582
STANDARD ERROR OF THE REGRESSION: 63.68 NORMALIZED: 0.8007

ORDINARY LEAST SQUARES
ANNUAL(1958 TO 1988) 31 OBSERVATIONS (3 OMITTED)
DEPENDENT VARIABLE: GNP
DATES OF OMITTED DATA: 1958 TO 1960

	COEFFICIENT	STD. ERROR	T-STAT	INDEPENDENT VARIABLE
	71.2155	23.91	2.978	CONSTANT
1	0.450729	0.2303	1.957	GNP LAG 1
2	-0.132629	0.2493	-0.5321	GNP LAG 2
3	-16.7742	10.45	-1.605	TELECOMM INVESTMENT LAG 1
4	-4.54687	10.60	-0.4288	TELECOMM INVESTMENT LAG 2

R-BAR SQUARED: 0.1370
DURBIN-WATSON STATISTIC: 2.1310
STANDARD ERROR OF THE REGRESSION: 61.68 NORMALIZED: 0.7345

CRITICAL F VALUE WITH 2 AND 26 DEGREES OF FREEDOM AT THE TEN PERCENT LEVEL = 2.519
GNP CAUSES TELECOMM INVESTMENT FVALUE: 6.520
TELECOMM INVESTMENT CAUSES GNP FVALUE: 3.869

All series deflated to 1982 dollars.

Table C.2: DRI Causality Tests
(Table continues on next page)

CAUSALITY ANALYSIS
MODIFIED SIMS'S TEST

TESTING TOTAL OUTPUT CAUSES TELECOMM INVESTMENT

(performed using first differencing)

ORDINARY LEAST SQUARES
ANNUAL(1958 TO 1988) 31 OBSERVATIONS (3 OMITTED)
DEPENDENT VARIABLE: TOTAL OUTPUT
DATES OF OMITTED DATA: 1958 TO 1960

	COEFFICIENT	STD. ERROR	T-STAT	INDEPENDENT VARIABLE
	97.5313	39.26	2.484	CONSTANT
1	0.281975	0.2191	1.287	TOTAL OUTPUT LAG 1
2	0.0729859	0.2354	0.3100	TOTAL OUTPUT LAG 2
3	53.8394	19.47	2.765	TELECOMM INVESTMENT
4	-64.3769	20.67	-3.114	TELECOMM INVESTMENT LAG 1
5	9.32644	20.81	0.4481	TELECOMM INVESTMENT LAG 2

R-BAR SQUARED: 0.3923
DURBIN-WATSON STATISTIC: 1.9119
STANDARD ERROR OF THE REGRESSION: 110.0 NORMALIZED: 0.7624

ORDINARY LEAST SQUARES
ANNUAL(1958 TO 1988) 31 OBSERVATIONS (3 OMITTED)
DEPENDENT VARIABLE: TOTAL OUTPUT
DATES OF OMITTED DATA: 1958 TO 1960

	COEFFICIENT	STD. ERROR	T-STAT	INDEPENDENT VARIABLE
	62.2361	42.61	1.461	CONSTANT
1	0.445152	0.2293	1.941	TOTAL OUTPUT LAG 1
2	0.0501950	0.2255	0.2226	TOTAL OUTPUT LAG 2
3	38.1950	20.65	1.849	TELECOMM INVESTMENT
4	-56.0177	20.33	-2.755	TELECOMM INVESTMENT LAG 1
5	15.1631	20.17	0.7516	TELECOMM INVESTMENT LAG 2
6	30.6756	17.52	1.751	TELECOMM INVESTMENT LEAD 1

R-BAR SQUARED: 0.4445
DURBIN-WATSON STATISTIC: 1.9108
STANDARD ERROR OF THE REGRESSION: 105.2 NORMALIZED: .7289

Table C.2: DRI Causality Tests
(Table continues on next page)

TESTING TELECOMM INVESTMENT CAUSES TOTAL OUTPUT

(performed using first differencing)

ORDINARY LEAST SQUARES
ANNUAL(1958 TO 1988) 31 OBSERVATIONS (3 OMITTED)
DEPENDENT VARIABLE: TELECOMM INVESTMENT
DATES OF OMITTED DATA: 1958 TO 1960

	COEFFICIENT	STD. ERROR	T-STAT	INDEPENDENT VARIABLE
	-0.0551743	0.4189	-0.1317	CONSTANT
1	0.548874	0.2027	2.708	TELECOMM INVESTMENT LAG 1
2	-0.169074	0.1938	-0.8722	TELECOMM INVESTMENT LAG 2
3	0.00478897	0.001732	2.765	TOTAL OUTPUT
4	0.00158492	0.002116	0.7489	TOTAL OUTPUT LAG 1
5	-0.00381126	0.002072	-1.840	TOTAL OUTPUT LAG 2

R-BAR SQUARED: 0.5114
DURBIN-WATSON STATISTIC: 1.8755
STANDARD ERROR OF THE REGRESSION: 1.037 NORMALIZED: 1.870

ORDINARY LEAST SQUARES
ANNUAL(1958 TO 1988) 31 OBSERVATIONS (3 OMITTED)
DEPENDENT VARIABLE: TELECOMM INVESTMENT
DATES OF OMITTED DATA: 1958 TO 1960

	COEFFICIENT	STD. ERROR	T-STAT	INDEPENDENT VARIABLE
	0.721109	0.4404	1.637	CONSTANT
1	0.517230	0.1735	2.982	TELECOMM INVESTMENT LAG 1
2	-0.232310	0.1669	-1.392	TELECOMM INVESTMENT LAG 2
3	0.00562630	0.001506	3.737	TOTAL OUTPUT
4	4.70281E-05	0.001878	0.02504	TOTAL OUTPUT LAG 1
5	-0.00385642	0.001770	-2.179	TOTAL OUTPUT LAG 2
6	-0.00415738	0.001375	-3.023	TOTAL OUTPUT LEAD 1

R-BAR SQUARED: 0.6434
DURBIN-WATSON STATISTIC: 2.0734
STANDARD ERROR OF THE REGRESSION: 0.8862 NORMALIZED: 1.597

CRITICAL F VALUE WITH 1 AND 24 DEGREES OF FREEDOM AT THE TEN PERCENT LEVEL = 2.927
TOTAL OUTPUT CAUSES TELECOMM INVESTMENT FVALUE: 3.505
TELECOMM INVESTMENT CAUSES TOTAL OUTPUT FVALUE: 10.446

All series deflated to 1982 dollars.

Table C.2: DRI Causality Tests
(Table continues on next page)

CAUSALITY ANALYSIS
MODIFIED SIMS'S TEST

TESTING GNP CAUSES TELECOMM INVESTMENT
(performed using first differencing)

ORDINARY LEAST SQUARES
ANNUAL(1958 TO 1988) 31 OBSERVATIONS (3 OMITTED)
DEPENDENT VARIABLE: **GNP**
DATES OF OMITTED DATA: 1958 TO 1960

	COEFFICIENT	STD. ERROR	T-STAT	INDEPENDENT VARIABLE
	51.1322	23.34	2.191	CONSTANT
1	0.227565	0.2295	0.9915	GNP LAG 1
2	0.204766	0.2672	0.7664	GNP LAG 2
3	25.9407	10.84	2.394	TELECOMM INVESTMENT
4	-26.0708	10.28	-2.537	TELECOMM INVESTMENT LAG 1
5	-0.530129	9.801	-0.05409	TELECOMM INVESTMENT LAG 2

R-BAR SQUARED: 0.2842
DURBIN-WATSON STATISTIC: 1.8735
STANDARD ERROR OF THE REGRESSION: 56.18 NORMALIZED: 0.6689

ORDINARY LEAST SQUARES
ANNUAL(1958 TO 1988) 31 OBSERVATIONS (3 OMITTED)
DEPENDENT VARIABLE: **GNP**
DATES OF OMITTED DATA: 1958 TO 1960

	COEFFICIENT	STD. ERROR	T-STAT	INDEPENDENT VARIABLE
	31.7004	25.42	1.247	CONSTANT
1	0.454139	0.2607	1.742	GNP LAG 1
2	0.129398	0.2615	0.4948	GNP LAG 2
3	16.0359	12.06	1.330	TELECOMM INVESTMENT
4	-21.2022	10.34	-2.051	TELECOMM INVESTMENT LAG 1
5	2.10739	9.580	0.2200	TELECOMM INVESTMENT LAG 2
6	15.9067	9.695	1.641	TELECOMM INVESTMENT LEAD 1

R-BAR SQUARED: 0.3354
DURBIN-WATSON STATISTIC: 1.8696
STANDARD ERROR OF THE REGRESSION: 54.13 NORMALIZED: 0.6446

Table C.2: DRI Causality Tests
(Table continues on next page)

TESTING TELECOMM INVESTMENT CAUSES GNP

(performed using first differencing)

ORDINARY LEAST SQUARES
ANNUAL(1958 TO 1988) 31 OBSERVATIONS (3 OMITTED)
DEPENDENT VARIABLE: TELECOMM INVESTMENT
DATES OF OMITTED DATA: 1958 TO 1960

	COEFFICIENT	STD. ERROR	T-STAT	INDEPENDENT VARIABLE
	0.206813	0.4493	0.4603	CONSTANT
1	0.492023	0.1759	2.798	TELECOMM INVESTMENT LAG 1
2	-0.118617	0.1699	-0.6981	TELECOMM INVESTMENT LAG 2
3	0.00796719	0.003328	2.394	GNP
4	0.00501181	0.003970	1.262	GNP LAG 1
5	-0.0119497	0.004003	-2.985	GNP LAG 2

R-BAR SQUARED: 0.5599
DURBIN-WATSON STATISTIC: 1.6969
STANDARD ERROR OF THE REGRESSION: 0.9845 NORMALIZED: 1.775

ORDINARY LEAST SQUARES
ANNUAL(1958 TO 1988) 31 OBSERVATIONS (3 OMITTED)
DEPENDENT VARIABLE: TELECOMM INVESTMENT
DATES OF OMITTED DATA: 1958 TO 1960

	COEFFICIENT	STD. ERROR	T-STAT	INDEPENDENT VARIABLE
	0.833195	0.4973	1.675	CONSTANT
1	0.452442	0.1625	2.785	TELECOMM INVESTMENT LAG 1
2	-0.173904	0.1579	-1.101	TELECOMM INVESTMENT LAG 2
3	0.00949437	0.003130	3.033	GNP
4	0.00300918	0.003752	0.8020	GNP LAG 1
5	-0.0115198	0.003681	-3.130	GNP LAG 2
6	-0.00664941	0.002948	-2.256	GNP LEAD 1

R-BAR SQUARED: 0.6288
DURBIN-WATSON STATISTIC: 1.7895
STANDARD ERROR OF THE REGRESSION: 0.9041 NORMALIZED: 1.630

CRITICAL F VALUE WITH 1 AND 24 DEGREES OF FREEDOM AT THE TEN PERCENT LEVEL = 2.927
GNP CAUSES TELECOMM INVESTMENT FVALUE: 3.076
TELECOMM INVESTMENT CAUSES GNP FVALUE: 5.815

All series deflated to 1982 dollars.

Table C.2: DRI Causality Tests

Appendix D

Additional Data Requirements and Recommended Methodological Improvements

I. TELECOMMUNICATIONS INVESTMENT

A. Need: An inventory of the elements that comprise the "Investment" category in each of the countries being compared.

For example, as noted above, the accounting treatment of initial labor costs incurred in connection with the public network is not the same in all countries. Once all the elements are identified, then adjustments should be made to the numbers associated with those items that the countries treat differently. When a given element can only be determined for some of the countries or an adjustment can only partially be made, then that element or adjustment should be omitted for all of the countries.

B. Need: Inclusion of "Other" Public Infrastructure Investment.

Customer premises equipment is a significant category for which country-by-country figures are not easily obtained. Data should also be collected or estimated for such telecommunications providers as alternative local service providers, mobile and cellular telephony, and point-to-point cable television systems, which are generally growing in importance.

In addition, statistics for all interexchange carriers should be included in the infrastructure investment total. Currently, only data for AT&T, MCI, and U.S. Sprint have been included in our investment numbers.

C. Need: Estimates of the magnitude of private telecommunications expenditures.

These, ideally, should be developed on a regular basis using a consistent, transparent methodology across countries.

D. Need: Adjustments to investment figures.

At minimum, adjustments should be made to reflect exchange rate differences, inflation, and differences determined in A. above. A categorization of investment by primary objective, *i.e.*, "modernization," "expansion," and "other" (such as replacement of a worn-out system, or where no one objective clearly drives the process), would be useful. It would also be highly desirable to develop a means of measuring the efficiency of a country's investment expenditures by tieing the outlays to productivity performance. Ideally, net investment should be derived on a comparable basis; to date, this has not been achievable due to "considerable differences in the interpretation of the concept of depreciation in the telecommunications sector."[1203] Another useful but difficult adjustment to make concerns the extent of the cost-lowering effect of economies of scale or scope on investment outlays. Finally, the effect of telephone company equipment purchases from an affiliated supplier should be estimated.[1204]

E. Need: More recent data.

The various analyses submitted in the inquiry generally suffered from a lack of current or very recent data for all or some of the countries being studied.

II. NON-INVESTMENT INDICATORS

A. Need: Greater comparability of service quality measurements across countries.

Various countries currently employ a myriad of service quality indicators.[1205] Multiple indicators that can be compared across countries should be developed because of the many dimensions of quality performance. Measures selected should include customer inputs through, *e.g.*, surveys, as well as technical (network) indices.

[1203] *See* ITU, *Yearbook of Public Telecommunications Statistic* 19 (1990).

[1204] One researcher estimates that the "relatively inefficient state" of the European CPE market has resulted in 40 percent higher prices compared to the United States and Japan. The analyst does not specify the causes of this inflation beyond the need for competition and the "currently fragmented European customer premises equipment market." *See Competition and Growth: Europe's Consumer Equipment Market*, Telecommunications, Nov. 1990, at 31. He implies that the phenomenon may be more evident in Italy and France (than in Germany and Spain), citing a perceived "prejudice against nonindigenous suppliers" with respect to the CPE market. *Id.* at 36.

[1205] For an excellent review of current quality measures that are used by various U.S. and foreign telephone companies, see *After the Break-Up* (B. Cole ed. 1991) (especially Chapter 6 contributions by R. Curry, J. Kraushaar, R. Gryb, J. Ake, T. Buzas, S. Berg, J. Lynch, Jr., and L. Cole); OECD, *Performance Indicators for Public Telecommunications Operators* (1990); Industry Analysis Division, Common (continued...)

Examples of indicators that should be considered are: customer perception surveys, call failure/success rate (network congestion), equipment blocking and failure (also called fault reporting or clearance rates), on-time service delivery (for service orders), dial tone delay, and operator response time.

III. GENERAL

A. *Need: More cooperation on collection of data and use of common measures.*

There should be greater sharing of data among countries for the purpose of developing common bases of comparison on a regular basis. Such commonality permits customers, providers, and public policy-makers to make meaningful comparisons in the new global context. If data are unreliable or not available, then the comparisons will send the wrong signals or no signals at all.

B. *Need: Better frames of reference.*

Better data, continuing availability, and commonality of measures are necessary, but not sufficient, to develop meaningful comparisons. We also require appropriate frames of reference to place the comparisons in the proper context. Optimal levels of capital expenditures, technology deployment, and service quality should be determined, but this is generally very difficult to do, in practice. Useful surrogates should be devised, such as distinguishing stages of development.

[1205] (...continued from preceeding page)
Carrier Bureau, Federal Communications Commission, *Update on Quality of Service for the Bell Operating Companies* (released June 14, 1990). In March 1991, the FCC initiated a proceeding on price cap service quality and infrastructure monitoring, seeking comments on proposed quality and infrastructure reporting requirements for U.S. LECs subject to a price cap regulatory regime. Public Notice, DA 91-299 (released Mar. 8, 1991).

Appendix E

Policies of Other Nations on Telephone Company Involvement in Cable

France

In France, there are no laws or policies restricting the state-owned monopoly telecommunications operator, France Telecom, from involvement in cable. France Telecom has invested heavily in research in video-telephony services, and in 1979, conducted an experimental project in Biarritz to test a wide variety of fiber optic applications, including pay-per-view television, video telephones, and on-line access to video libraries. By the end of 1987, France Telecom had begun construction of 50 local video communications networks serving close to 300 communities. France Telecom also owns 51 percent of Telediffusion de France (TDF), the leading supplier of broadcast programming, and plans to offer new audiovisual services on both cable and fiber networks, including pay-per-view and high definition television.[1206]

Federal Republic of Germany

In the Federal Republic of Germany, the state-owned telecommunications carrier, Deutsche Bundespost Telekom, is responsible for all communications transmission systems, and thus owns and operates both the cable and telephone infrastructure. It has actively been constructing a national broadband network, with the expectation that this infrastructure will help spread ISDN services to users in metropolitan areas. As discussed in Chapter 5, the Deutsche Bundespost Telekom is undertaking a number of pilot projects to provide both television and telephone services via fiber optic cable to the home.[1207]

[1206] *See* M. Steckel and M. Fossier, FRANCE TELECOM: An Insider's Guide 44 (1991).

[1207] *See also Telekom Installs Millionth KM of Optical Fibre*, Inf. Telecom et Telematique, Feb. 27, 1991, at 1; *Telekom and Raynet Fibre Optic Project in Cologne*, Funkschau, June 29, 1990, at 16; *Fibre Optic Pilot Project for Domestic Users*, Handelsblatt, June 2, 1990, at 21.

United Kingdom

In order to become cable operators in the United Kingdom, entities must obtain both a franchise to serve a local area and licenses to provide service. Under current law, the national telephone companies (namely, BT and Mercury) are directly barred from conveying video programming over their telephone networks to customers; their parents, affiliates, and subsidiaries are free to apply for a local cable franchise, but must construct a separate system (not integrated with the telephone network) to offer cable service.[1208] BT played a significant role in some of the nation's early cable franchises, although it recently disposed of some of the interests which it held.[1209]

In its recent duopoly review, the U.K. government decided to revise its policies governing the provision of cable service by the national telephone companies. The government concluded that BT and Mercury should continue to be barred from conveying video programming over their main networks for the next ten years, but it is prepared to lift this restriction in seven years if it determines that such action will promote more effective competition in the provision of telecommunications and entertainment services.[1210]

The government's decision to maintain in the short term a general prohibition on the provision of cable programming by BT and Mercury appears in large part to have been motivated by a desire to protect the infant cable industry in Great Britain. Compared to the United States, cable television is still relatively undeveloped in Great Britain: while franchises now have been awarded in areas covering nearly 70 percent of the country, most of those franchises have been awarded only in the last year or two, so that licensees are just now beginning to build their networks. Moreover, in 1989, the government announced that, at least initially, it envisioned awarding only one franchise per area, so that the current incumbent licensees generally entered the marketplace with the expectation that they would not face direct competition in the immediate future.[1211] The government noted that one advantage of allowing the prohibition on the provision

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[1208] *See* British Telecom, *Competitive Markets in Telecommunications* 17, 33 (1990); Department of Trade and Industry, *Competition and Choice: Telecommunications Policy for the 1990s* 40, 50 (Nov. 1990) (*Duopoly Review*). However, the government has licensed a trial by BT of the integrated provision of entertainment and telephony signals over a fiber optic network. *Id.* at 21, 41.

[1209] *Duopoly Review, supra* note 1224, at 44.

[1210] *Id.* at 49-50.

[1211] *Id.* at 45-46.

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of programming to expire after some specified period of time was that BT would have an incentive to build a broadband network in the interim, knowing that it would be free to provide entertainment services over that network at a date certain.[1212] Moreover, BT will be free to seek permission to provide video programming directly to any unfranchised area beginning in 1994.[1213]

Japan

In Japan, as a practical matter, all telephone companies—both NTT, the dominant carrier, and the numerous new competing common carriers—appear to be barred from leasing facilities to cable operators on a common carrier basis by the so-called "integration of software-hardware" principle, which requires licenses of broadcast stations and cable systems to assume responsibility for both transmission facilities and programming. There are some indications in other contexts, however, that the government's allegiance to this principle may be beginning to erode.[1214] Different rules and policies would govern if a telephone company were to seek to provide video programming over its own facilities. However, to date, no telephone company has formally applied to the Japanese MPT to become a cable operator, and it is unclear how that body might rule on such an application. Nor has the MPT announced an official policy on the degree of permissible affiliation between telephone companies and cable operators.[1215] The parent company of one Japanese telephone company (Tokyo Tsushin Network, a regional Type I carrier) has minority interests in a number of small urban cable television companies.[1216]

Canada

In Canada, there are no laws that explicitly bar telephone companies from involvement in cable, but as a matter of regulatory policy, the Canadian Radio-Television and Telecommunications Commission will not license telephone companies under federal jurisdiction to become cable operators. The rationale behind this policy is to allow the

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[1212] *Id.* at 48.

[1213] *See* Department of Trade and Industry Press Release, *Telecommunications - Peter Lilley Sets Agenda for the 90's* at 5 (Mar. 5, 1991).

[1214] *See* N. Koike, *Cable Television and Telephone Companies: Towards Residential Broadband Communications Services in the United States and Japan* 33-34, 42-43, 123, 125 (1990).

[1215] *Id.* at 44, 109.

[1216] *Id.* at 166-67.

In Canada, a telephone company-cable distributor consortium has conducted a pilot project in Rimouski, Quebec, offering a variety of interactive, digital services, including voice telephony, videotex, and channels for both cable service and video-on-demand.

Appendix F

Availability and Affordability of Telephone Service in the United States

In this appendix we present a statistical profile of the availability and affordability of telephone service in this country. The tabulations that we have developed, relying heavily on FCC efforts, show time series trends, particularly since 1980, relating to telephone penetration rates and the annual rate of change in the consumer price index (CPI) for selected items, including telephone service.

As shown in Table F.1, the number of residence main telephones per 100 households grew significantly during a 41-year period prior to the breakup of the Bell System. The penetration rate grew steadily, if not spectacularly, during most of the time interval, rising every year between 1950 and 1979. In 1980, the rate matched the level of the previous year; by 1981, the rate had declined by .5 percentage points.

Post-divestiture trends may be discerned from Table F.2, using a new methodology developed by the FCC in conjunction with the Census Bureau. Between 1984 and 1990, an already-high penetration rate of 91.6 percent rose to 93.3 percent in 1990. Again, the change proved to be a slow but steady increase. To properly interpret the numbers, it should be understood that changes of less than or equal to .3 percent for nonconsecutive years and .2 percent for consecutive years are not statistically significant. For example, the change from 92.3 in 1986 to 92.4 in 1987 is not statistically significant. However, the increase of almost two (1.9) percent since the Bell System breakup represents a genuine improvement in the penetration rate rather than the manifestation of a sampling error.

Table F.3 shows that during the post-divestiture period, Whites have generally registered telephone penetration rates in the low and middle 90 percentiles, while the two other groups (African-Americans and Hispanic-Americans) exhibited rates in the low 80s. The trends are improving for minority groups: while the majority rate has risen by 1.5 percent over the interval, the rates for African-Americans and Hispanic-Americans have grown by 4.4 percent and 2.2 percent, respectively. Although many registered declines

Year	Residence Main Telephones Per 100 Households**	Year	Residence Main Telephones Per 100 Households**
1950	61.8	1966	86.2
1951	64.0	1967	87.2
1952	66.0	1968	88.7
1953	68.0	1969	90.0
1954	69.6	1970	90.7
1955	71.5	1971	90.9
1956	73.8	1972	91.9
1957	75.5	1973	92.9
1958	76.4	1974	93.3
1959	78.0	1975	93.4
1960	78.6	1976	93.8
1961	79.1	1977	94.5
1962	80.4	1978	95.5
1963	81.5	1979	96.2
1964	82.8	1980	96.2
1965	84.7	1981	95.7

* Includes Alaska and Hawaii beginning in 1960.

** Due primarily to a change in the Census household definition in 1960, the total number of households increased relative to the number counted under the old methodology. As a result, the penetration also changed. For example, in 1959 the revised figure (78.0) represented a 1.0% increase over the figure calculated according to the old formulation.

SOURCE: *Bell System Statistical Manual, 1950-1981,* June 1982, Table, at 504.

Table F.1: Telephone Penetration Rates in the United States*
(Pre Divestiture 1950-1981)

between 1984 and 1987 before rising again, households of all sizes and ethnicities generally showed higher penetration rates from 1984 to 1990.[1217]

Year	Average Annual Percentage of Households with Telephones**
1984	91.6
1985	91.8
1986	92.3
1987	92.4
1988	92.7
1989	93.1
1990	93.3

* Based on a nationwide sample of approximately 58,000 households per survey.

** Figure for each year represents an average of the results of the three surveys (March, July, and November) conducted each year. The critical value for two consecutive years is .2 %; for nonconsecutive years is .3%. Where changes between are less than or equal to these percentages, the changes are likely to be attributable to sampling error rather than movement in penetration.

SOURCE: A. Belinfante, Industry Analysis Division, Common Carrier Bureau, FCC, *Telephone Subscribership in the U.S.*, February 1991, Table 2.

Table F.2: Telephone Penetration Rates in the United States*
Post Divestiture 1984-1990

Based upon data collected by the Department of Labor's Bureau of Labor Statistics and analyzed by the FCC, the price of telephone service (as measured by the consumer price index (CPI) and as shown in Table F.4) increased less rapidly from 1980 to 1990 than that of all goods and services, all services, food, housing, electricity, and medical care. In turn, the CPI for telephone services rose more on an annual basis than the CPIs for

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[1217] Because the critical value exceeds the change between years for those of Hispanic origin between 1984 and 1990, the actual numbers are likely affected by sampling error. However, the statistical significance for at least one household size (*i.e.*, 1-person) that follows a similar pattern suggests that the general trend for the ethnic group is increasing penetration. Concerning the "Total" rates for the other two ethnic groups, the increases do not appear to be subject to such error.

Year Household Size	Average Annual Percentage of Households with Telephones**		
	White Caucasian	African American	Hispanic Origin
1984:			
Total	93.2	79.8	80.9
1 Person	90.3	74.9	72.9
2-3	94.5	82.3	82.0
4-5	93.9	81.8	83.9
6+	89.8	76.3	79.2
1987:			
Total	93.8	81.8	83.0
1 Person	91.3	77.8	79.5
2-3	95.1	83.9	83.8
4-5	94.3	83.6	84.4
6+	89.8	77.4	80.6
1990:			
Total	94.6	83.5	82.7
1 Person	92.5	80.2	76.2
2-3	95.8	86.0	84.2
4-5	95.0	84.0	84.6
6+	90.2	78.5	80.6

* Based on a nationwide sample of approximately 58,000 households per survey.

** Figure for each year represents an average of the results of the three surveys (March, July, and November) conducted each year. The critical values relating to Total, 1, 2-3, 4-5, and 6+ persons, for sampling of White Caucasian are .5%, 1.0%, .7%, 1.0%, and 2.4% respectively; of African-Americans, 1.9%, 3.6%, 3.0%, 4.1%, and 7.1%, respectively; and of Hispanic Origin, 4.4%, 10.7%, 6.9%, 8.1%, and 12.9%, respectively. Where changes between years are less than or equal to these percentages, the changes are likely to be attributable to sampling error rather than movement in penetration.

SOURCE: A. Belinfante, Industry Analysis Division, Common Carrier Bureau, FCC, *Telephone Subscribership in the U.S.*, September 1991, Tables 3, 8.

Table F.3: Telephone Penetration Rates in the United States*
By Household Size and Ethnicity 1984, 1987, 1990

clothing and transportation during the same period. It should be noted that the CPI for public transportation increased more than that for telephone services.[1218]

Item	Annual Rate of Change in CPI Selected Items (%)
Medical Care	8.1
All Services	6.0
Housing	4.7
All Goods & Services	4.7
Electricity	4.5
Food & Beverages	4.3
Telephone Services	4.2
Transportation	3.8
Apparel and Upkeep	3.2

SOURCE: Industry Analysis Division, Common Carrier Bureau, FCC, *Trends in Telephone Service*, at 6, Table 3 (released Aug. 7, 1991).

Table F.4: Relative Affordability of Telephone Service in the United States Selected Items 1980-1990

[1218] *See* Industry Analysis Division, Common Carrier Bureau, Federal Communications Commission, *Trends in Telephone Service* at 6, Table 3 (released Aug. 7, 1991).

* U.S. G.P.O.:1992-311-895:60425

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